

ALLEN'S
HUMAN ANATOMY.

SECTION VI.

ORGANS OF SENSE, ORGANS OF DIGESTION,
AND GENITO-URINARY ORGANS.

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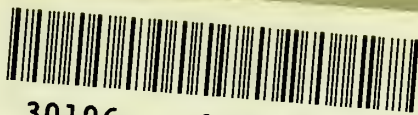
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A SYSTEM OF
HUMAN ANATOMY.

INCLUDING ITS
MEDICAL AND SURGICAL RELATIONS.

BY
HARRISON ALLEN, M. D.,
PROFESSOR OF PHYSIOLOGY IN THE UNIVERSITY OF PENNSYLVANIA, ETC., ETC.

ILLUSTRATED WITH THREE HUNDRED AND EIGHTY FIGURES ON ONE HUNDRED AND NINE PLATES, MANY OF WHICH
ARE BEAUTIFULLY COLORED. THE DRAWINGS BY HERMANN FABER, FROM DISSECTIONS BY THE AUTHOR.
ALSO, UPWARDS OF TWO HUNDRED AND FIFTY WOODCUTS IN THE TEXT.

SECTION VI.—ORGANS OF SENSE, OF DIGESTION
AND GENITO-URINARY ORGANS.



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PROSPECTUS
—OF—
A SYSTEM OF HUMAN ANATOMY,
INCLUDING ITS
MEDICAL AND SURGICAL RELATIONS.

—BY—
HARRISON ALLEN, M. D.,
PROFESSOR OF PHYSIOLOGY IN THE UNIVERSITY OF PENNSYLVANIA, ETC., ETC.
WITH
A CHAPTER ON HISTOLOGY,

—BY—
E. O. SHAKESPEARE, M. D.,
OPHTHALMOLOGIST TO THE PHILADELPHIA HOSPITAL.

To be completed in Six Sections, containing about 550 pages of letter-press, illustrated with 380 figures on 109 plates, many of which are beautifully colored. The drawings by Hermann Faber, from dissections by the Author. Also, 250 woodcuts in the text.

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"	VI. ORGANS OF SENSE, OF DIGESTION AND GENITO-URINARY ORGANS, - - - - -	with 17 plates containing 71 figures.

The plan and scope of the work may be gathered from the following brief extract from the introduction.

"It is the design of this book to present the facts of human anatomy in the manner best suited to the requirements of the student and practitioner of medicine. The author believes that such a book is needed, inasmuch as no treatise, as far as he knows, contains, in addition to the text descriptive of the subject, a systematic presentation of such anatomical facts as can be applied to practice.

A book which will be at once accurate in statement and concise in terms; which will be an acceptable expression of the present state of the science of anatomy; which will exclude nothing that can be made applicable to the medical art, and which will thus embrace all of surgical importance, while omitting nothing of value to clinical medicine,—would appear to have an excuse for existence in a country where most surgeons are general practitioners, and where there are few general practitioners who have no interest in surgery."

As a brief introduction to the essential features of the volume, attention is invited to the kinds of knowledge of the human body which the physician demands.

First. An exact acquaintance with the form and construction of the organs of the body. But, inasmuch as an anatomical fact is of little use unless the range of application of the fact is known, the due connection between the normal condition of the organs and their variations within the limits of health will receive proper attention, accordingly the typical description of each organ will be followed by a brief statement of such variations.

Second. The physician demands a knowledge of the relations of the parts. This information it is necessary to possess in performing operations and in explaining signs and symptoms.

Third. The physician needs some account of the uses of the organs. This subject overlaps physiological anatomy. That much only will be succinctly given as may be said properly to illustrate the subject from an anatomical point of view, and at the same time be free from controversy.

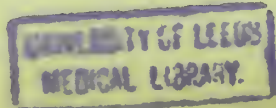
Fourth. The physician must have a true conception of the nature and general behavior of morbid processes, and of the manner in which such processes are modified by locality. His comprehension of the changes due to diseased action in a given place must be fairly proportional to his knowledge of the normal anatomy of that place. This subject, which will receive the name of *localization of diseased action*, will be illustrated for the most part by concise statements of recorded cases, in which the essential feature of each case will be emphasized, and the bearing it has on the subject treated of clearly shown. In presenting anatomical features in explanation of given lesions, or of signs or symptoms, care has been taken to give the sources of the statements made.

"Among other matters, the book will be found to contain an elaborate description of the tissues; an account of the normal development of the body; a section on the nature and varieties of monstrosities; a section on the method of conducting post-mortem examinations; and a section on the study of the superficies of the body taken as a guide to the position of the deeper structures. These will appear in their appropriate places, duly subordinated to the design of presenting a text essentially anatomical."

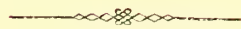
In the preparation of this elaborate work no pains have been spared. The illustrations of normal anatomy, with a few exceptions, are from original dissections, engraved on the stone, with the name of every part clearly drawn upon the figure after the manner of "Holden" and "Gray," and in every typographical detail it has been the effort of the publishers to render the volume worthy of the distinguished position anticipated for it.

Each section will be enclosed in an individual portfolio, thus preserving all in a perfect condition in case it is subsequently desired to bind them as a volume.

HENRY C. LEA'S SON & CO., PHILADELPHIA.



ALLEN'S
HUMAN ANATOMY.



ORGANS OF SENSE,

ETC.

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ORGANS OF SENSE.

ERRATA.

On page 593, first column, third line from top, *insert* the words "in part" *after* the word "muscles." On same page, second column, sixth line from top, *for* "phthisis bulbo" *read* "phthisis bulbi." On same column, twenty-sixth line from the top, *omit* the word "artery" *after* the word "ciliary."

On page 597, first column, twentieth line from the bottom, *insert* the word "visual" *before* the word "axis."

On page 598, first column, first line, *insert* the word "until" *before* the word "recently." On same page, same column, *for* "into" *read* "toward." On same page, same column, *in advance* of word "pulsate" *insert* the word "sometimes."

On page 599, first column, fourteenth line, *for* "capsule" *read* "suspensory ligament;" and on same page, same column, sixteenth line, *in advance* of the words "the vitreous body" *insert* the words "hyaloid membrane of."

On page 599, second column, eleventh line from top, *between* the words "suspensory ligament" and "the posterior capsule and the lens" *insert* the words "the fibres to."

On page 631, in description of Fig. 160, *for* "back" *read* "side."

On page 760, first column, twelfth line from top, *for* "749" *read* "750."

On page 760, second column, sixth line from bottom, *for* "ducts" *read* "educts."

On page 764, first column, seventh line from the bottom, *for* "male" *read* "mole."

On page 776, first column, eleventh line from bottom, *for* "If the centre of attraction is the" *read* "If the centre of attraction of the."

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Under the head of the eyelids may be considered the following subjects:—

The Skin.

The Palpebral Fissure.

The Palpebral Ligaments.

The Tarsal Cartilages.

The Meibomian Glands.

The Eyelashes.

The Muscles.

The Skin of the Eyelids is thin, nearly translucent, and without subcutaneous fat. The skin of the

orbitale). This is a fibrous expansion continuous with the borders of the orbit. It is greatly strengthened toward the free edges of the palpebral fissure by the *tarsal cartilages* (palpebral cartilage), which, although so separately denominated, are only differentiated portions of the palpebral ligament, being dense fibrous tissue with some admixture of elastic tissue. Each "cartilage" is thick at its free border, but thin at the upper. The *upper tarsal cartilage* is the larger, of crescentic shape, and measures nine lines long, and four lines wide in the centre. The *lower tarsal cartilage* is nearly fusiform, or is ribbon shaped.

The palpebral ligament lies as a compact layer two lines in length between the outer canthus and

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ORGANS OF SENSE.

THE EYE.

THE Eye is described as composed of the *eyeball*, or the organ of vision, and its *appendages*. It is convenient to describe the appendages of the eye before the eyeball itself.

THE APPENDAGES OF THE EYE.

The Appendages of the Eye are—

- I.
 - The Eyelids.
 - The Conjunctiva.
 - The Eyebrows.
 - The Capsule of Tenon.
 - The Periocular muscles.
- II. The Lachrymal Apparatus.

I. THE EYELIDS AND CONJUNCTIVA, AND THE EYEBROWS.

THE EYELIDS AND CONJUNCTIVA.

The Eyelids. The *eyelids* are special structures, composed principally of skin, conjunctiva, and interposed muscle and so-called cartilage, and are designed to cover the front of the eye, as in the act of winking and in sleeping.

Under the head of the eyelids may be considered the following subjects:—

- The Skin.
- The Palpebral Fissure.
- The Palpebral Ligaments.
- The Tarsal Cartilages.
- The Meibomian Glands.
- The Eyelashes.
- The Muscles.

The Skin of the Eyelids is thin, nearly translucent, and without subcutaneous fat. The skin of the

upper lid is derived from the brow, that of the lower lid from the cheek. The inner surfaces of the eyelids are in contact with the palpebral conjunctiva. The eyelids secure their form, and in great measure their efficiency, through the tarsal cartilages.

The Palpebral Fissure. The space between the eyelids is called the palpebral fissure. It is an elliptical opening, varying in size in different individuals, and in the same individual at different times as in the changes of expression.—The angles of the fissure are called the *canthi*. The *outer canthus* (external angle) is acute, and defined by the tarsal cartilage; the *inner canthus* (internal angle) is rounded and prolonged as a horizontal *cul-de-sac* beyond the lachrymal puncta. The free edges of the eyelids form the upper and lower borders of the palpebral fissure, are flat, and come directly in contact in winking; they are furnished in front with eyelashes. The opposed borders of the inner canthus alone are rounded and nearly hairless.

The Palpebral Ligament. The form of the eyelid is determined by the palpebral ligament (septum orbitale). This is a fibrous expansion continuous with the borders of the orbit. It is greatly strengthened toward the free edges of the palpebral fissure by the *tarsal cartilages* (palpebral cartilage), which, although so separately denominated, are only differentiated portions of the palpebral ligament, being dense fibrous tissue with some admixture of elastic tissue. Each "cartilage" is thick at its free border, but thin at the upper. The *upper tarsal cartilage* is the larger, of crescentic shape, and measures nine lines long, and four lines wide in the centre. The *lower tarsal cartilage* is nearly fusiform, or is ribbon shaped.

The palpebral ligament lies as a compact layer two lines in length between the outer canthus and

the orbit, where it has received the name of the *external canthal ligament* (external palpebral ligament), and is continuous with the tarsal cartilage. Towards the inner angle of the palpebral fissure, it strengthens the opposed border of the canthus, and is continuous with the tendon of the Orbicularis Palpebrarum muscle.

The Meibomian glands (palpebral glands). The posterior surfaces of the tarsal cartilages are grooved for the reception of numerous glands, which open upon the margins of the eyelids. They vary in number from twenty-five to thirty in the lower lid, and from thirty-five to forty in the upper. Each gland is composed of imperfectly defined lobules attached to a single straight duct. The secretion of the Meibomian glands is sebaceous in character, and serves to lubricate the edges of the lids, and to prevent the lachrymal secretion from flowing out upon the face.

The Eyelashes. The edges of the palpebral fissure are furnished with numerous curved hairs, forming the eyelashes. They are arranged in two or three irregularly wavy rows; the upper set curve downward and forward, the lower set upward and forward.

The Muscles. The muscles of the eyelids are three in number, namely: (1) The palpebral fibres of the Orbicularis Palpebrarum, which are arranged in a thin layer parallel to the line of greatest length of the eyelids. (2) The Orbito-Palpebral fibres (H. Müller and Sappey), which are situated deeper than the preceding, and are arranged at right angles, *i. e.*, vertically to the foregoing. (3) The fibres of termination of the Levator Palpebræ muscle, which, by their insertion into the palpebral ligament, and association with the orbito-palpebral fibres, may be here included.

The Conjunctiva. The *conjunctival chamber* is the space between the eyelids and the eyeball. It is lined with a mucous membrane, the *conjunctiva*, and receives the secretion of the *lachrymal* and *conjunctival glands*. The conjunctiva is continuous with the nasal mucous membrane through the lachrymo-nasal ducts. It is composed of two portions, a palpebral and an ocular.

The *palpebral layer* is in close connection with the eyelids. It is thinner and more vascular than the ocular layer. The vessels are derived from the superior and inferior ophthalmic arteries.

The *ocular layer* consists of a scleral portion and a corneal reflection of its epithelium. The *scleral portion* is freely movable upon the eyeball—a feature due to the necessity of motion between the eyeball and

the orbit. The vessels are derived from the lachrymal branches of the ophthalmic, and anastomose with those of the ciliary arteries. The nerves are derived from the ophthalmic division of the fifth nerve. At the junction of the scleral portion with the cornea, a crescentic fold called the *limbus conjunctivæ*, is seen in the aged, which measures half a line in thickness. The *corneal reflection* is very thin and transparent. It is closely adherent to the cornea, and in health is without bloodvessels.

The portion between the palpebral and ocular layers presents some features of interest, being near the bases of both lids, and termed the *fornix conjunctivæ*. The conjunctiva is here loosely attached, and is rich in minute racemose glands. Toward the palpebral portion, namely, at the termination of the tarsal cartilage, are numerous papillæ (conjunctival papillæ), best marked in the upper eyelid, which are engorged in catarrhal conditions.—The union between the two layers at the inner canthus marks the *lachrymal caruncle*. This structure occupies the position of the internal canthus, and is slightly movable by traction of the eyelids, yet it is concealed by their closure; it is composed for the most part of sebaceous glands, and is furnished with a few small white hairs. To the outer side of the caruncle is a vertical fold of the conjunctiva, the *plica semilunaris*; this fold apparently belongs to the scleral portion, but is believed to be the rudiment of the nictitating membrane of lower animals, under which term is included a supplementary eyelid acting from within outward. It contains a small quantity of unstriated muscular fibres.

Minute Anatomy. The conjunctiva is composed of three layers: the stratified pavement epithelium, the basement membrane upon which the former rests, and the connective tissue matrix of the mucous membrane proper, arranged after the manner found on other mucous surfaces. Upon the cornea the first two layers alone are seen. It is the rapid disappearance of the epithelium that causes the duski-ness of the cornea to be so soon apparent after death.

Under the head of the *oculo-palpebral groove* may be described a space between the eyeball and the eyelid. It is six or seven lines in depth in the upper eyelid, and four lines in depth in the lower.

REMARKS.—An instrument penetrating the eyelids at a point beyond the limits of the oculo-palpebral groove, would not involve the conjunctiva.¹ Malgaigne fixes this limit for the upper eyelid at seven or eight lines from the edge of the lid, and for the

¹ Richet, Anat. Chirurg., 1860, 314.

lower eyelid at three-quarters of a line.—Emphysema of the lids may occur from fracture of the ethmoidal plate. A blow upon the face at the region of the eye will, as a rule, not involve the eye itself, but will be received upon the malar bone and the supra-orbital ridge. Thus an ecchymosis from this cause will be more apt to be located in the integuments about the eye than in the conjunctival or subconjunctival surfaces. The lower eyelid sags in facial palsy.

THE EYEBROWS.

The Eyebrows are curved lines defined by numbers of stout hairs situated between the regions of the forehead and of the eyes, and nearly corresponding to the supraorbital arches.¹

The eyebrow is divided into two parts by the directions of the hairs composing it. The hairs of the median third of each brow tend to arrange themselves in vertical or oblique lines, and may merge with those of the eyebrow of the opposite side. The hairs of the remaining two-thirds are nearly horizontal, and become less compactly disposed near the temple. Occasionally one or the other of these divisions may be absent. The median division would appear to answer to the pilose wart commonly present in quadrupeds, which is determined by the presence of terminal trophic filaments of the supraorbital nerve.

The eyebrows serve to deflect the perspiration of the brow from the eyes, and to act, when shaggy, as a shade to the eye when the light falls from above.

II. THE LACHRYMAL APPARATUS.

The Lachrymal Apparatus (figs. 2 and 3, Plate XCVI.) consists of—

The Lachrymal Gland.

The Canaliculi.

The Lachrymal Sac.

The Lachrymo-Nasal Duct.

The Lachrymal Gland is an almond-shaped body half an inch broad and three-quarters of an inch long, situated within the orbit towards its outer side. It is lodged within the lachrymal fossa of the frontal bone, and is protected in part by the external lateral process. It is obscurely lobulated, is of a pale reddish color, and presents a convex surface above, and a concave one beneath. It is fixed to the periosteum of the orbit by a few tendinous fibres, and is a race-

mose gland, closely resembling the true salivary gland, and for the most part inclosed within a thin capsule. The lachrymal gland is divided into two portions, the superior and the inferior. The *superior portion* is much the larger and the more compact of the two. The *inferior portion* is lodged in the subconjunctival connective-tissue at the superior fornix conjunctivæ. The ducts of the lachrymal glands are from ten to twelve in number, and open into the superior palpebral sinus at its outer third, and at a point about one-fourth of an inch above the tarsal cartilage. A few minute glands belonging to the lower division may open at or below the external angle.

The *arteries* of the lachrymal gland are derived from the ophthalmic artery. The *nerves* arise from the ophthalmic branch of the fifth nerve.—Both vessels and nerves enter the glands from below and behind.

The Canaliculi are little canals running from the edges of the eyelids to the lachrymal sac. They are two in number, one for either lid. Each begins in the centre of the lachrymal papilla by a minute orifice, the *punctum lachrymale*, which is directed toward the eyeball. From this point the canaliculus abruptly widening descends at first and then passes forward and inward. The entire length of each canaliculus is about five lines, and its width two lines. The two canaliculi converge towards the lachrymal sac. The lower is somewhat the larger, and is placed nearly horizontally. As a rule they open separately between one and two lines below the summit of the sac, on the orbital side.

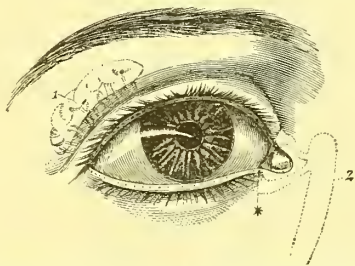
Each canaliculus is lined by a pavement epithelium resting upon an abundant connective-tissue stroma, the whole being inclosed by the longitudinal fibres of the Orbicularis Palpebrarum muscle and the skin. The palpebral ligament gives strength to the outer wall of each canaliculus, and passes inward to form the internal palpebral ligament.

The Lachrymal Sac is the expanded upper half of the lachrymo-nasal passage. It receives the canaliculi, and is continuous with the lachrymo-nasal duct below. It is of an oval shape, slightly widened above, and is lodged in the sulcus (lachrymal groove) between the crest of the lachrymal bone and the nasal process of the superior maxilla, just behind the insertion of the internal palpebral ligament. It measures six lines in length by about ten in width, but is narrower below. The lachrymal sac is straight along its inner border where it is in connection with

¹ Some writers define the eyebrows as composed, not only of the supraorbital hairs, but of skin, fat, subcutaneous tissue, and muscle-fibres. The term *region of the eyebrow* may be reserved for this locality.

the boundaries of the sulcus, and is held in position elsewhere by an extension of the orbital periosteum, as well as by a slip prolonged inward from the internal palpebral ligament, which is strengthened by Horner's muscle. The main portion of the palpebral ligament crosses it in front, where, according to Luschka, some of the oblique facial fibres of the *Orbicularis Palpebrarum* arise.

Fig. 126.



The conjunctival space, showing position of lachrymal gland, canaliculi, and lachrymal sac. 1, lachrymal gland; 2, lachrymal sac; * inferior canaliculus.

The Lachrymo-nasal Duct extends from the lachrymal sac to the nose. It measures seven lines in length, being slightly narrower in the middle than elsewhere. Circular at its beginning, it is slightly compressed laterally below. Being directed downward and slightly outward, it terminates at the roof of the inferior meatus. It is throughout adherent to the bony walls of the ductus ad nasum (*q. v.*), and is lined with a ciliated form of epithelium.

Several folds of a valve-like character have been described in connection with the lachrymal apparatus; one is situated just within each lachrymal punctum; one at the orifice of the canaliculi in the lachrymal sac; others within the lachrymal nasal duct, and, finally, one at its nasal outlet.

REMARKS.—The mechanism of the flow of tears appears to be as follows: The act of winking forces the tears into the palpebral chamber. The tears suffuse the conjunctiva, and afterwards collect between the margins of the eyelids and the eyeball, where, as a glistening layer, they can always be seen before they fall. The puncta collect this fluid and

conduct it by capillary attraction into the canaliculi, and thence into the lachrymal sac; while from that point it descends by gravitation along the lachrymo-nasal duct into the nose. This process, apparently so simple, is complicated by the fact that the abundant muscular tissue about the canaliculi contracts their lumen and prevents, except at the moment of the closure of the eyelids, the relaxation sufficient to permit the outflow of tears.

THE CAPSULE OF TENON.

The Capsule of Tenon (ocular fascia, orbito-ocular aponeurosis, albugineal membrane, tunica vaginalis bulbi) is the name given to the fascia between the walls of the orbit and the eyeball. Its outer surface is distinguished by a number of trabecular bands, which either end in the lobules of periocular fat, or secure attachment to the walls of the orbit. The inner surface is smooth. The fascia is continuous posteriorly with the dura mater, through the sphenoidal fissure and the optic foramen, and anteriorly it is lost upon the subconjunctival connective tissue. The inner aspect of the capsule is lined with epithelial cells, and incloses a lymph-space. The posterior half is much stouter than the anterior half, and the capsule has been compared to a socket, within which the eyeball moves. The anterior half is thin and loosely connected with the eyeball. Posteriorly, the capsule is perforated by the optic nerve and the ciliary nerves and vessels, and anteriorly, by the periocular muscles.

The relation of the fascia to these muscles and adjacent parts is as follows: The external (lateral) portion of the fascia supports the lachrymal gland, and sends off a trabecular band of attachment to the outer wall of the orbit at the malo-frontal suture. The Superior and External Recti muscles give off bands similar to those of the orbital wall posteriorly. The internal (median portion) receives trabecular support from the wall of the orbit posteriorly, near the origins of the Internal Rectus and the Inferior Rectus muscles, and anteriorly at the region of the trochlear process, not only near the insertion of the Superior Oblique, but near that of the Levator Palpebræ and Superior

EXPLANATION OF PLATE XCIII.

Fig. 1. View of the tongue, with attachments to the epiglottis, as seen from above.

Fig. 2. A view of the cartilages of the external nose.

Fig. 3. A semi-diagrammatic view of the sinuses of the dura mater, showing the manner by which venous blood enters the sinus system from within the nasal chamber at the foramen cæcum.

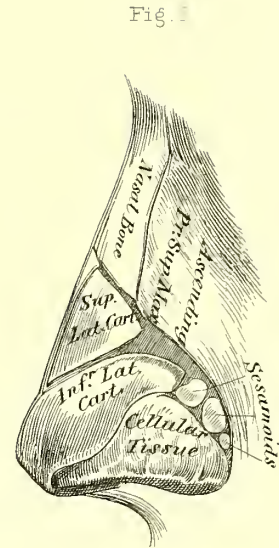
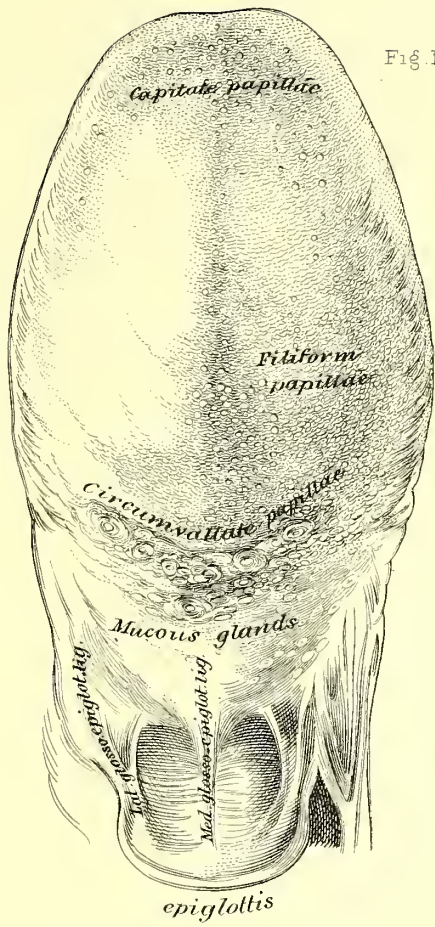
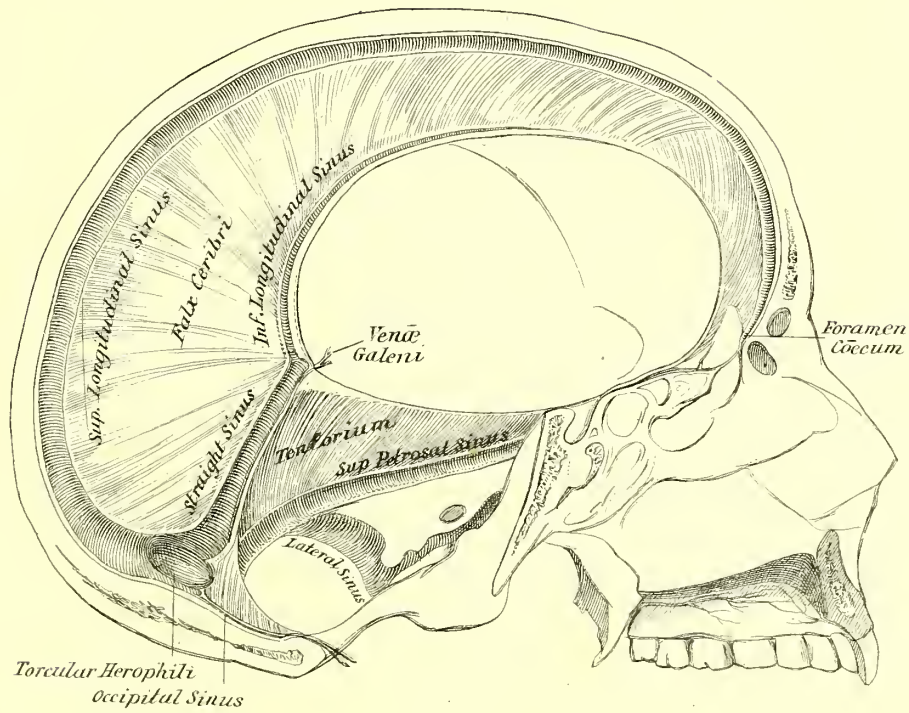
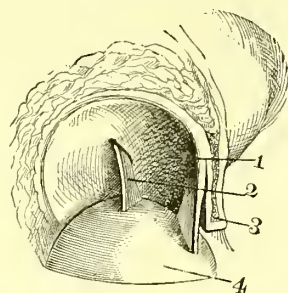


Fig. 3.



Rectus. It also strengthens the internal palpebral ligament, and receives muscular fibres from the Levator Palpebræ muscle. The Inferior Oblique muscle is the only one of the series which is not fixed to some part of the orbital wall by a trabecular band. The function of these bands is obscure, though they seem to check undue action of the muscles.

Fig. 127.



1. The posterior half of the capsule of Tenon. 2. The External Rectus.
3. The upper eyelid. 4. The posterior half of the sclera.

The muscles themselves are united by the fascia in such wise that imperfect sheaths are seen inclosing them. The existence of such sheaths is denied by Liebreich, but most authorities agree in using the term "sheath" in the sense that the fascia is in relation with the muscles, save at their insertions, as an appreciable connective-tissue envelope. The sheaths of the External and Superior Recti muscles are continuous with the external portion of the fascia; the sheaths of the Internal Rectus and the two oblique muscles are continuous with the internal portion of the fascia; while the sheath of the Levator Palpebræ gives off slips of attachment to both the above-named portions. Occasionally, dispersed muscular fibres can be seen passing from one muscle to another, along the lines of their fascial connection.¹

Boucheron² describes a bursa lying beneath the capsule of Tenon and each Rectus muscle, at a point just before the muscle penetrates the fascia.

Bloodvessels.—The arteries of the conjunctiva are derived from the palpebral and lachrymal arteries, which form a series of loops near the margin of the cornea. The conjunctival arteries are movable with the scleral conjunctiva, and in this way are readily distinguished from the subconjunctival, which are derived from scleral vessels, and are disposed in a zone of minute lines, radiating from the corneo-

scleral junction. In clinical studies the appearances of the conjunctival and subconjunctival vessels are of importance. The conjunctival vessels become injected, and form coarse networks in conjunctivitis, giving the eye a red appearance. The subconjunctival vessels become full in iritis, but, by reason of the modification of the white color of the sclera, the appearance of the eye is not red but pink, and the conjunctival vessels may be but moderately involved, if at all.—Pterygium is the name given to a vascular connective-tissue growth from the conjunctiva over the cornea.

REMARKS.—The clinical applications of a knowledge of the appendages of the eye are the following: (a) to the eyelids and conjunctiva; (b) to the lachrymal apparatus; (c) to the capsule of Tenon.

(a) *The Eyelids and Conjunctiva.* The sagging of the lower eyelid, with the escape of tears from the conjunctival space to the cheek, is a sign of facial palsy.—The integument of the eyelid, owing to the absence of fat in the subcutaneous tissue, permits moderate degrees of inflammation to cause great swelling. Owing to the firm union between the conjunctiva and the tarsal cartilages, little disposition exists for effusion to take place between them. The opposite condition obtains between the conjunctiva and the sclera, which permits of the following epitome.

(1) The tarsal cartilages are united to the edges of the orbit by a membrane continuous with their upper edges. The substance of the eyelid outside of the layer of the tarsal cartilages is also attached to the edge of the orbit. Extravasation from the vertex to the eyelids is guided by the above layers to the eyelids, the ocular conjunctiva remaining free.

(2) No barrier exists, however, to the flow of liquids between the conjunctiva and the periocular space. Hemorrhage arising within this space, or from a source within the cranium, will cause the blood-clot and the ecchymosis attending it easily to invade the ocular conjunctiva. Thence it can pass to the palpebral conjunctiva, and in advanced cases may stain the entire thickness of the lower eyelid.

(3) In framing the differential diagnosis of fracture of the skull and of superficial ecchymosis, the following statements may prove useful: Subcutaneous ecchymosis of the eyelids is a sign of hemorrhage having taken place peripherally to the conjunctival sac, or, in other words, outside of the skull, except in the lower eyelid, where it *may* be (when studied with reference to the condition of the entire orbit and its contents) diagnosed as the last stage of peri-

¹ Fr. Merkel, Handbuch der Gesamten Augenheilkunde, 1874, i. 57. This authority is followed in the main features of the account of the capsule of Tenon.

² Annales d'Oculistique, lxxx. 1879, 10.

ocular hemorrhage. The presence of subconjunctival ecchymosis is evidence of blood having escaped *behind* or centrally to the conjunctival sac, or, in other words, at some point in the periocular space, and ordinarily from a source *inside* the skull.—In the paroxysms of whooping-cough, extravasations of blood may occur beneath the scleral conjunctiva.—The deposition of products of inflammation beneath the scleral conjunctiva receives the name *chemosis*.

(4) The value of distinguishing the tegumental and conjunctival layers of the eyelid is borne out in Arlt's method of operating for inversion of the eyelashes. The eyelashes belonging to the upper eyelid are raised with the skin layer, by carefully splitting the lid between the row of lashes and the tarsal cartilage. The latter structure, together with the conjunctiva, is allowed to remain in contact with the eyeball. Then, by removing from the skin layer an elliptical piece, and uniting the edges of the wound thus produced, the free edge containing the eyelashes is raised and permanently everted.

Incisions in the eyelids should always be made parallel to the course of the palpebral muscle fibres.

The tactile sensibility of the conjunctiva is very great. The moment the person to whom an anæsthetic agent is administered ceases to wink when the scleral conjunctiva is touched, general anæsthesia may be considered to be established. Sensibility to pain, however, is less decided. High grades of inflammation may exist in the conjunctival tissue, and but slight pain result.

(b) *The Lachrymal Apparatus.* The tears flowing from the lachrymal gland pass downward into the conjunctival sac, and thence, flowing across the entire conjunctival space, escape by the canaliculi into the lachrymal sac, and thence, by the lachrymo-nasal duct, into the nose. If the tears formed be in excess of the capacity of the conjunctival space, they flow over upon the cheek. The clinical conditions related to this act are confined to the lachrymal gland, the conjunctiva, and the apparatus of conduction thence to the nose.

From the position of the *lachrymal gland*, it must

follow that enlargement of this body from inflammation, by a tumor or other cause, will compress the contents of the orbit, and tend to press the eyeball downward and inward. Subconjunctival infiltration will occur at the upper and outer portions of the conjunctival sac, and the edge of the swollen gland can be detected at the same point. The gland is liable to become the seat of cystic growths, which are caused by the stoppage of some of its ducts. The retention of tears in the *conjunctival sac* is secured by the tonicity of the muscle fibre, so that when this tonicity is impaired from any cause, the tears collect in the interval between the scleral and tarsal conjunctiva. This condition is especially noted in the lower eyelid of elderly persons. A moderate amount of retention of tears near the lower canaliculus is normal, and has received the name of the *lacus lachrymarum*. The position of the *punctum* of the *lower canaliculus*, as already mentioned, is one favorable to the flow of tears from the lacus directly into the lachrymal sac. The sagging of the lower eyelid, inflammatory depositions, or the presence of any growth which presses upon the punctum from within, may prevent the normal adaptation of the punctum against the sclera. As a consequence, the tears cannot flow readily into the canaliculus, and the efficiency of the lachrymal apparatus is impaired. The *lachrymal sac*, from its intimate union with the periosteum, is liable to involvement in scrofulous diseases of the nasal bones and of the orbit. Extension of inflammatory processes from the walls of the sac to the subcutaneous connective is common, and in acute conditions rapidly involves the region of the lids and face. The amount of infiltration modifies the normal relation of the sac to the superficial parts, and it may become a matter of considerable difficulty to determine the true position of the sac. In connection with this the following rule may prove of value. To ascertain the position of the lachrymal sac, draw a line from the wing of the nose to the outer border of the supraorbital arch. Then bisect the middle of this line by a second, which will, when produced upward, cross the root of the nose. The

EXPLANATION OF PLATE XCIV.

Fig. 1. A horizontal section of the left eye (semi-diagrammatic).

Fig. 2. The plan of construction of the crystalline lens.

Fig. 3. The intraocular image of the optic disk, as seen with the ophthalmoscope.

Fig. 4. The plan of vascular supply of the eye.

Fig. 5. A dissection of the orbit, exhibiting the manner of vascular supply.

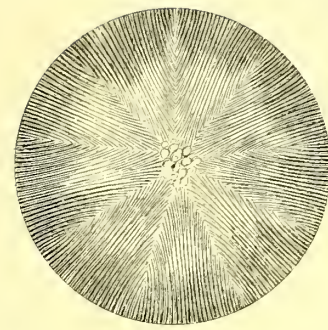
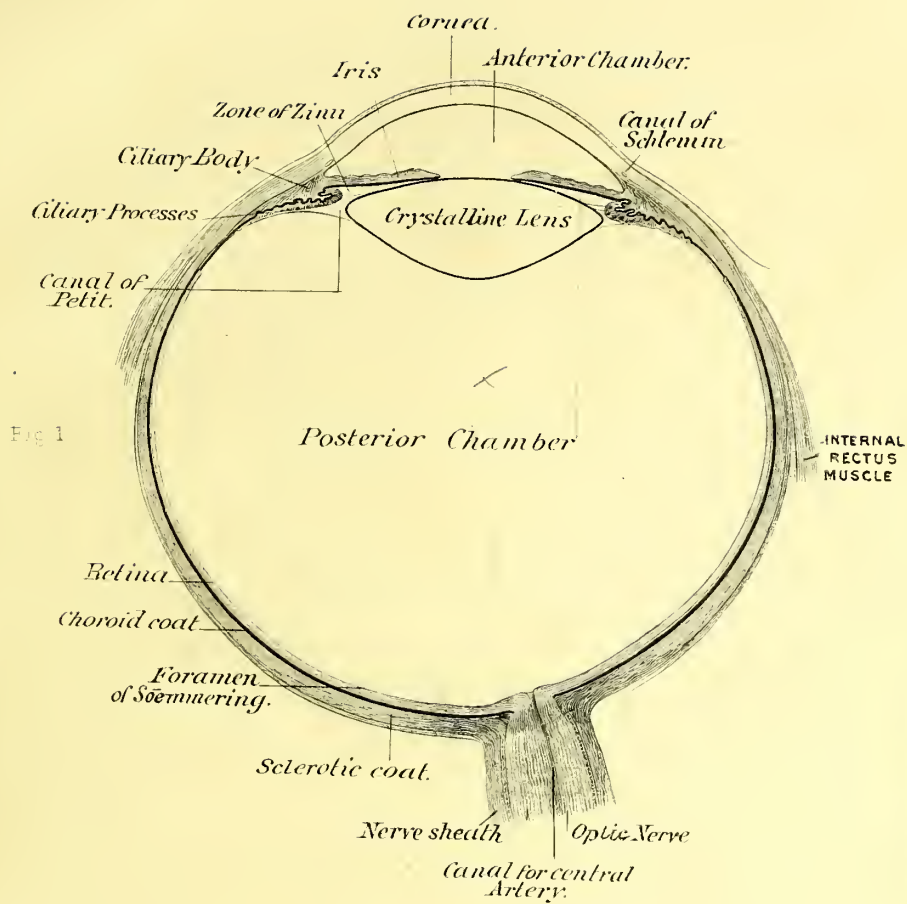


Fig. 3

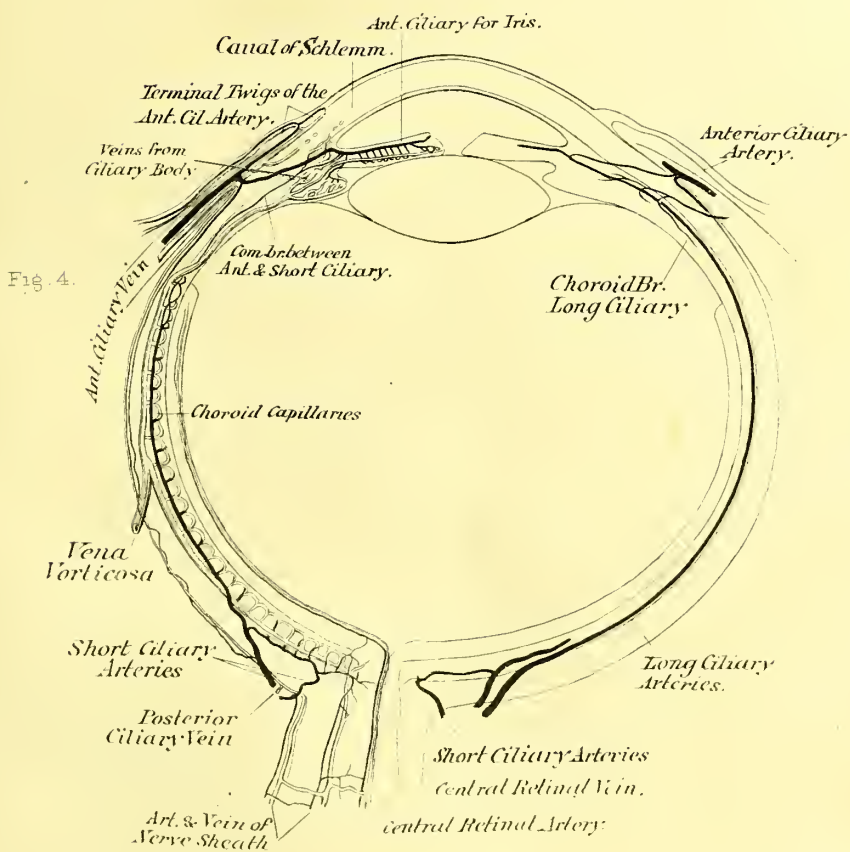
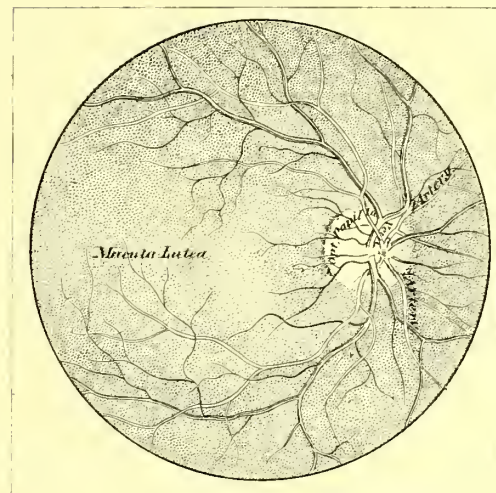
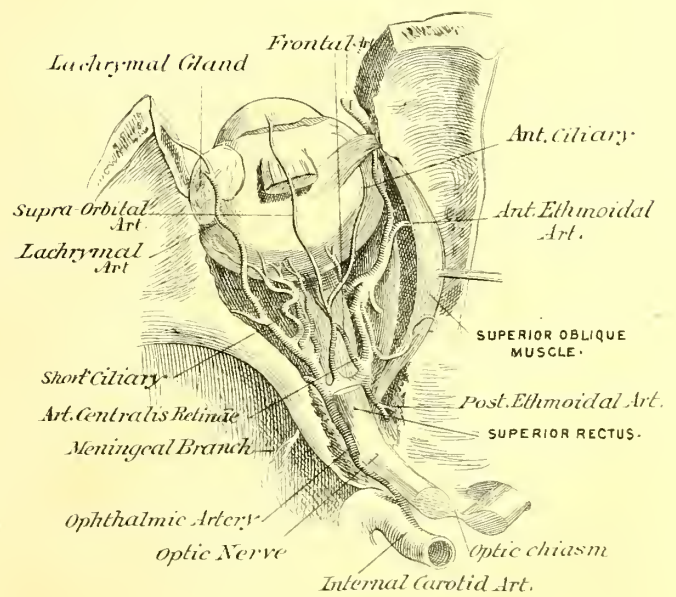


Fig. 5



second line will exactly cross the position of the lachrymal sac.

(c) *The Capsule of Tenon.* In periocular inflammation, tension may be maintained by the resistance presented by the capsule. In performing operations for strabismus, it is of importance to remember that the capsule may aid in maintaining erroneous dispositions of the eyeball after all the muscular bands which have been involved are divided.

THE EYEBALL.

The Eyeball is a subglobular figure, the periphery of which is composed of the cornea and the sclera. It is attached to the optic nerve as a berry is to its stem. The choroid coat and the retina are layers arranged concentrically to the sclera, and the vitreous humor and the lens occupy the interior of that portion of the eyeball defined by the sclera. The aqueous humor lies in the eyeball between the plane of the anterior termination of the sclera and the cornea.

The Eyeball is thus composed of—

- The Cornea.
- The Sclera.
- The Iris.
- The Choroid.
- The Retina.
- The Vitreous Humor.
- The Lens.
- The Aqueous Humor.

THE CORNEA.

The Cornea is the transparent portion of the outer covering of the eye. It forms a membranous structure, which projects by a distinct sharp curvature in advance of that of the sclera. It is nearly circular in form, measuring five lines transversely, which is slightly in excess of the perpendicular diameter, and is $\frac{1}{2}$ to $\frac{3}{2}$ of an inch in thickness (the outer edge becoming somewhat the thicker). The cornea constitutes about one-fifth of the periphery of the eyeball, and is attached to the sclera as a watch crystal is set in its case. Anteriorly it is bathed by the lachrymal secretion, and posteriorly by the aqueous humor.

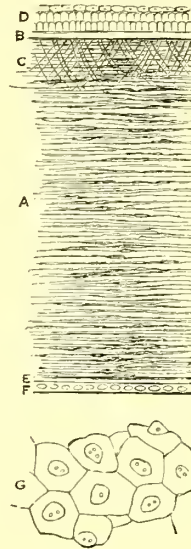
Viewed from behind, the cornea is circular in form, and presents a sharply defined border; viewed from in front, it is more oval in form, and presents a border which insensibly merges into that of the sclerotic coat. In a section which involves both the cornea and the sclera, the border of the cornea is seen to be slightly bevelled from before backward, owing to

the disposition of the sclera to overlap the cornea in front.

Structure. The cornea, when studied by histological methods, presents for examination the following layers:—

- (1) The anterior epithelial.
- (2) The anterior basement membrane.
- (3) The proper substance of the cornea.
- (4) The posterior membrane.
- (5) The posterior epithelial.

Fig. 128.



The plan of construction of the cornea. *A, C*, the proper substance; *B*, anterior basement membrane; *D*, the anterior epithelial membrane (all the cells should be nucleated); *E*, the posterior basement membrane; *F*, the posterior epithelial membrane; *G*, cells of corneal epithelium (more highly magnified).

(1) The anterior epithelial membrane (first layer) (*D*, Fig. 127) is continuous with the ocular conjunctiva. The cells of the first row are columnar; the others are at first rounded, but become flattened toward the surface.

(2) The anterior basement membrane (Bowman's membrane) (*B*, Fig. 127).

(3) The proper substance (parenchyma of the cornea) (*A, C*, Fig. 127) is apparently homogeneous, but under the action of reagents a complicated structure, based upon modifications of connective-tissue, is demonstrable. The essential features of such modifications are seen in the alternation of planes or laminae (some sixty in number), within which are recognized numbers of connective-tissue corpuscles, elongated in the lines of the lamellar planes. Indistinct interlacings of fibrils may be seen at the margins of the cornea, assuming toward the surface an oblique arrangement.

Placed between the laminae is a matrix or connecting medium containing small, flattened spaces. These are homologous with the connective-tissue spaces elsewhere. Within them are situated irregularly stellate corpuscles

(corneal corpuscles). The cornea is non-vascular in health, but is nourished by the colorless ingredients of the blood passing through the lamellar interspaces.

(4) The posterior basement membrane (membrane of Descemet, membrane of Demours, posterior elastic lamina) (*E*, Fig. 127) is better defined than the anterior. It is a firm, elastic, resistant membrane, which is continuous from the corneal margin through a network of fibres (ligamentum pectinatum iridis) with the anterior basement membrane of the iris, as well as with the choroid and sclerotic coats. In the angle between the iris and the cornea just beyond the posterior basement membrane is a system of *cavernous spaces* (spaces of Fontana) which are occupied by the aqueous humor. (See Fig. 129.)

(5) The posterior surface of the preceding membrane is covered with a single layer of epithelial cells (*F*, Fig. 127), which presents the same features as those in the other portions of the anterior chamber.

Extending around the cornea, just in advance of the corneo-scleral junction, is a small canal called the *canal of Schlemm*. It is lined with epithelial cells, and is probably of the nature of a venous sinus.

The nerves from forty to forty-five in number are derived from the ciliary nerves. They freely anastomose between the laminae, forming the primary plexus, which supplies for the most part the substantia propria. From this a secondary plexus is formed, which lies beneath the epithelium, and sends delicate branches among the epithelial cells.

Variation.—The curves of the cornea are subject to many minute variations which determine the nature of optical defects included under the term astigmatism. Infrequently the cornea is conical in form.

REMARKS.—The cornea is of a singularly tough consistence, and serves, by this quality as well as by its thickness, the purpose of an admirable organ of protection to the iris. While frequently the seat of lesion, the result of blows or wounds from missiles moving with great force, it successfully resists the more common causes of injury.

The laminated structure of the cornea is demonstrated in studying the effects of diseased action. In the vascular opacity of the cornea (pannus), which so

frequently accompanies granular lids, the anterior layers of the cornea, in the opinion of some observers, is the seat of a new growth of cells. Similar growths occur beneath the anterior epithelial membrane. Pus are sometimes seen lying between the laminae of the cornea, and constitutes the condition which has received the name of *onyx*. The laminae present various degrees of resistance to ulcerative action, as is well illustrated in the so called serpiginous ulcer.

The aqueous humor pressing against a deep corneal ulcer can bulge forward the base (through the elastic quality of the posterior basement membrane) until it forms a convex swelling on the front of the eyeball.

The marginal border of the cornea is subject to a form of fatty degeneration which has received the name of the *arcus senilis*.

The cornea is nourished by imbibition of the plasma, or by the circulation of this fluid through the lymph-spaces. In abnormal conditions, bloodvessels are developed, as in *pannus*, and may become large and abundant. The repair of injuries of the cornea is often followed by dense white opaque scars.

In performing the operation of extraction of the crystalline lens for cataract, it is necessary to remember that the opening through which the lens is to be passed must be a trifle larger than the lens itself, so that the size of the incision must be proportioned to the diameters of the lens. The margin of the cornea, as seen in the undissected eye, is overlapped by the sclera. An incision through the sclera a short distance back of this margin will permit the knife to enter the anterior chamber. Such a section is selected in performing the first stage of the operation for extraction of the lens as devised by Von Graefe.

THE SCLERA.

The Sclera (sclerotic coat) is the fibrous framework or envelope of the eyeball. The anterior part as exposed within the palpebral fissure, where it is called the "white of the eye," is covered with the conjunctiva. The rest of the ball is surrounded by

EXPLANATION OF PLATE XCV.

Figs. 1 and 2. The structure of the cornea, as seen when magnified.

Fig. 3. A vertical frontal section of the left eye and of the nasal chamber of the same side.

Fig. 4. A semi-diagrammatic view of the stem of the brain, exhibiting the origin of the optic nerves.

Fig 1

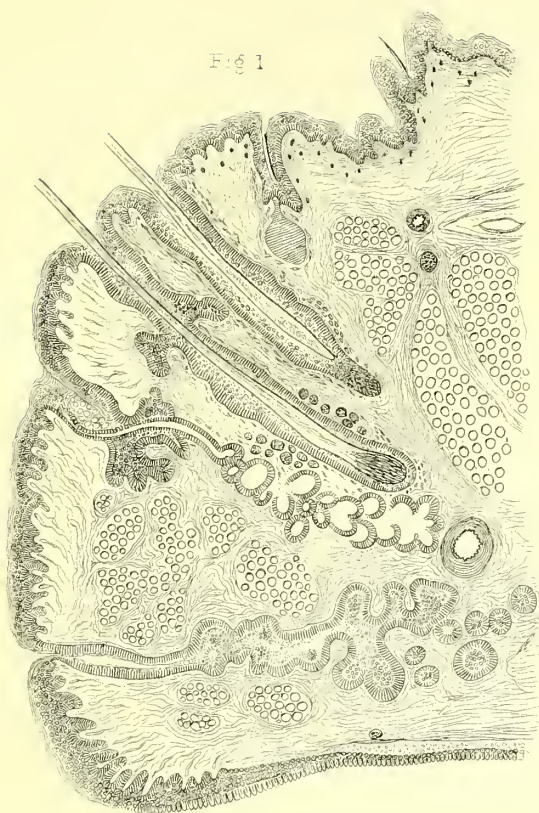


Fig 2

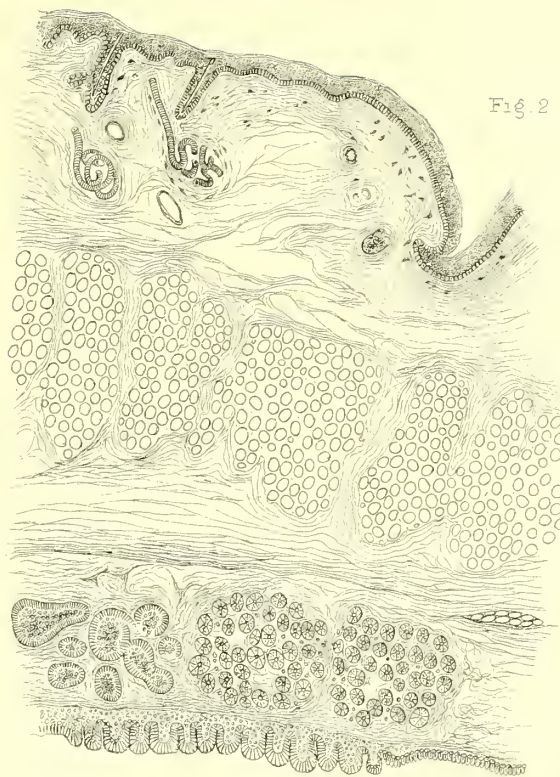


Fig 3

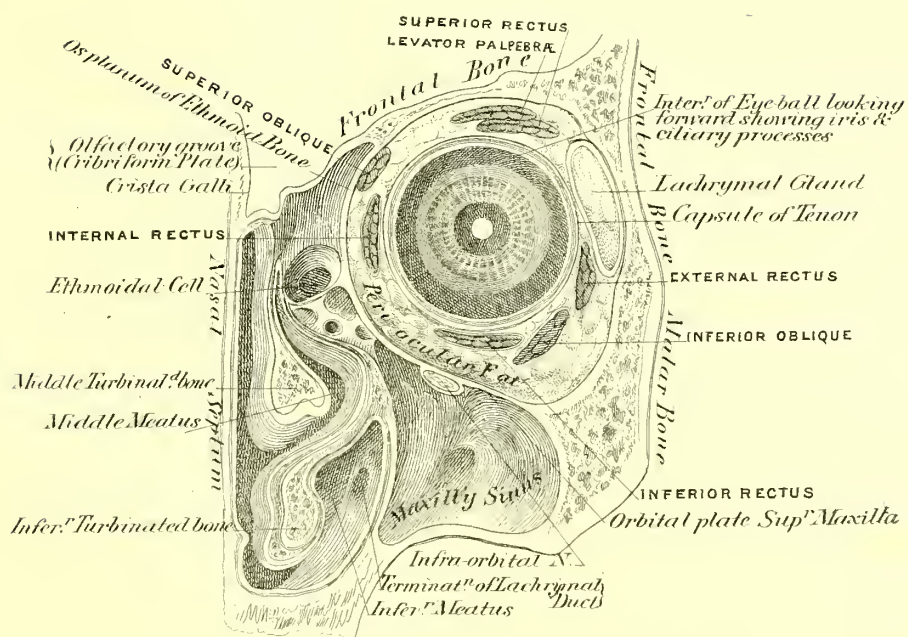
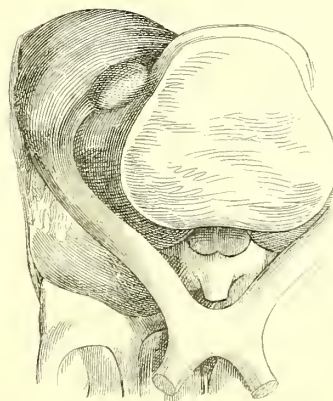


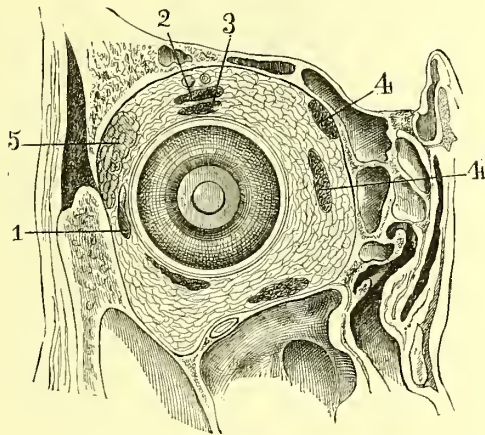
Fig 4



fat, from which it is separated by the capsule of Tenon, and receives the insertion of the straight and oblique periocular muscles.

The sclera is thicker posteriorly than anteriorly. It is cup-shaped in form, and is perforated behind, or at its base, by the optic nerve; while it is open in front for union with the cornea. The corneal opening is a little wider without than within. The optic nerve is received within the sclerotic coat one-tenth of an inch to the inner side of the antero-posterior axis of the eyeball. The nerve-fibres yield their neurilemma to the sclerotic coat, while passing through a sieve-like arrangement of scleral fibres, which has received in consequence the name of *lamina cribrosa*.

Fig. 129.



A frontal section of the orbit and contents—anterior half. 1. External Rectus; 2 Levator Palpebrae; 3. Superior Rectus; 4. Superior Oblique; 5. Lachrymal gland. The eyeball is surrounded by fat. The osseous structures to the median side of the orbit represent the ethmoidal cells and other parts of the ethmoid bone and vomer. To the lateral side are seen the malar bone and the Temporal muscle.

The membrane is white upon its outer surface, but brownish upon its inner, which has, from this fact, been called the *lamina fusca*. Upon this surface are found faint groovings for the long ciliary nerves.

Structure.—The fibres of the sclera arrange themselves into two more or less distinct sets, viz., the longitudinal and transverse. Between these a number of elastic filaments are sparsely distributed. The fibres of the tendons of the straight muscles are continuous with the longitudinal fibres, while those of the oblique muscles are continuous with the circular. The sclera is pierced about the entrance for the optic nerve by a number of canals, which extend perpendicularly or obliquely through the membrane, and are occupied by the ciliary arteries and nerves. The membrane is further pierced toward the corneal margin by several minute openings for the entrance of veins.

REMARKS.—The sclerotic coat, when softened by inflammatory process, may be distended by intra-ocular pressure to such a degree as to permit the choroid coat to be seen through the outstretched interlacing bands.—The coat is thicker than is normal in hypermetropia and in phthisis bulbo, and is thinner than is normal in myopia; from its tough fibrous character it bears well the presence of sutures.

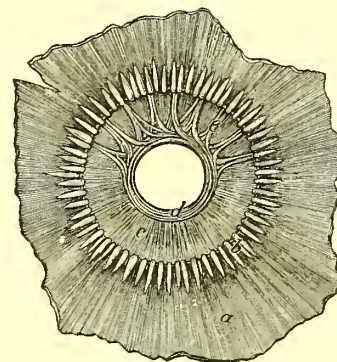
The eyeball, when the eyelids are closed, is turned slightly upward. If a pointed instrument pierce the centre of the upper lid, it will not wound the cornea, but it will wound the sclera at a point below the cornea.

THE CHOROID COAT.

The Choroid Coat (choroidea) is the vascular membrane of the eye. It is of a dull brownish color, and lines the sclerotic coat. Anteriorly it is continuous with the iris, and posteriorly is pierced by the optic nerve.

The choroid coat presents two layers, an outer and an inner.¹ The *outer layer* (lamina supra-choroidea) is a thin connective-tissue layer, resembling the lamina fusca of the sclera. It contains lymph-spaces which are continuous with the lymph-space of the capsule of Tenon. The *inner layer* (choroid proper) is the vascular layer, being composed of a network of vessels. The *arteries* are derived from the ciliary artery, and pierce the sclera around the optic nerve. They pass at first forward and finally inward, to end in the

Fig. 130.



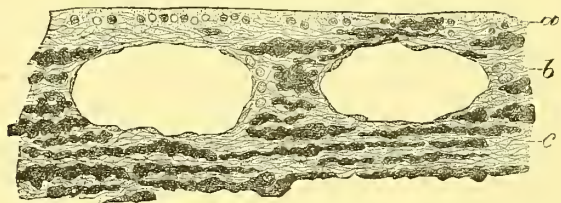
The ciliary processes and iris, seen from behind. *a*, choroid coat; *b*, ciliary processes; *c*, iris-radiating fibres; *d*, iris-circular fibres.

radiate capillaries.—The *veins* of the choroid coat form figures somewhat similar to those of the terminal arteries, but pierce abruptly the sclerotic mem-

¹ Formerly the eighth layer (pigment layer) of the retina (*q. v.*) was described with the choroid coat.

brane about midway between the cornea and the entrance of the optic nerve.

Fig. 131.



Transverse section through the choroid coat of the ox. Magnifying power about 250. *a*, chorio-capillaris, outside this is a layer of elastic fibrils, shown on the left of the figure; *b*, the layer of large veins, *venæ vorticosæ*; *c*, the outer layer, containing numerous pigmented connective-tissue cells flattened in a direction parallel to the surface.

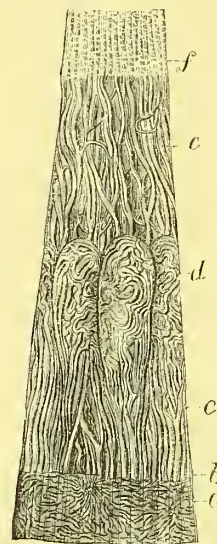
At the terminal portion of the choroid membrane, viz., at the point of junction with the iris, are found a number of folds of the choroid coat, known as the *ciliary processes*. They are club-shaped—the thicker ends projecting inward—about seventy in number, and arranged radially about the peripheral margin of the iris. Between the processes which form the larger group are placed a number of smaller ones.—Collectively the ciliary processes constitute the *ciliary body*.—This term is also used to include the entire thickness of the choroid, which corresponds in position to the ciliary processes. In the latter sense the ciliary body may be said to be that thickened portion of the choroid coat which is defined internally by the ciliary processes, externally by the sclera. It is continuous posteriorly with the choroid proper, and anteriorly with the iris. It is occupied by the ciliary muscle.

The Ciliary Muscle is a small triangular group of unstriated muscular fibres, having a tendinous origin from the corneo-scleral junction to the inner side of the canal of Schlemm. It is composed of two sets of fibres, the radiate and the circular. The *radiate fibres* (meridional fibres) are inserted into the ciliary processes. The *circular fibres* (circular ciliary ligament) lie to the inner side of the preceding fibres, and pass

circularly around the eye, within the zone of the ciliary processes.

The ciliary muscle, while properly embraced within the account of the choroid coat, is found to be in

Fig. 132.



Bloodvessels (injected) of the iris and choroid membrane of the eye of a child. *a*, Capillaries of the choroid; *b*, position of ora serrata of the retina; *c*, *b'* bloodvessels derived from *d*, those of the ciliary processes, and from *e*, those of the iris; *f*, capillary network of the pupillary border.

a measure distinct from it, inasmuch as its radiate fibres are firmly attached to the corneo-scleral junction. The structure separates the choroid membrane from the iris, as the ciliary processes separate the pigment layer of the retina from the uvea of the iris.

THE IRIS.

The Iris is a circular muscular membrane, situated in the anterior chamber between the lens and the cornea. It is placed nearly in a vertical plane, its posterior surface resting (near the centre) on the capsule of the lens. The iris is perforated by the round opening of the *pupil* (pupillary margin), which is not situated in the axis of the eye, but is a little

EXPLANATION OF PLATE XCVI.

Fig. 1. A longitudinal section of the optic nerve and of the optic papilla magnified.

Fig. 2. A diagrammatic figure of the lachrymal apparatus.

Fig. 3. A dissection of the face, showing the position of the lachrymal nasal duct. (For *lachrymal duct*, read "lachrymo-nasal duct.")

Fig. 4. A horizontal section of the right eye and orbit, exhibiting the relation of the optic nerve and of the internal and external recti muscles.

Fig. 5. A transverse section of the optic nerve magnified.

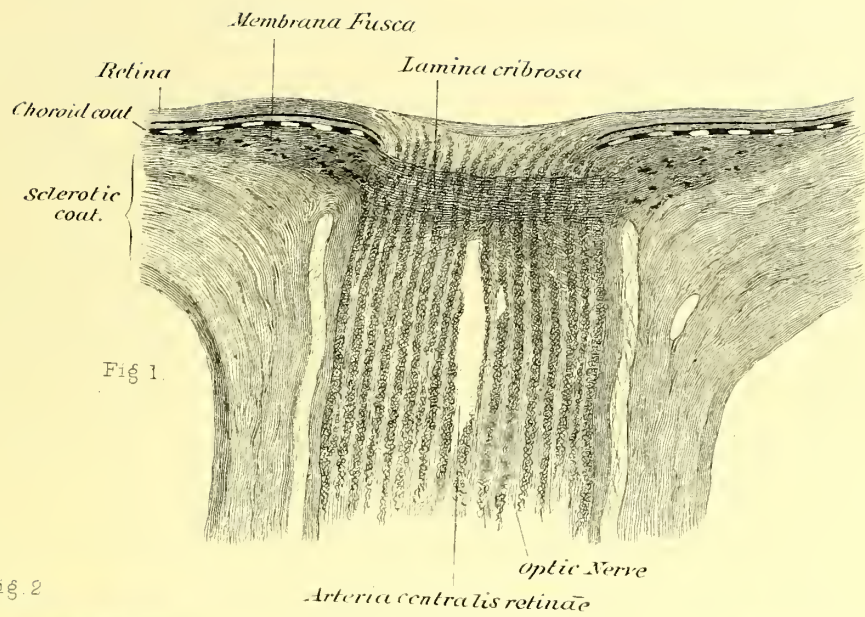


Fig 3

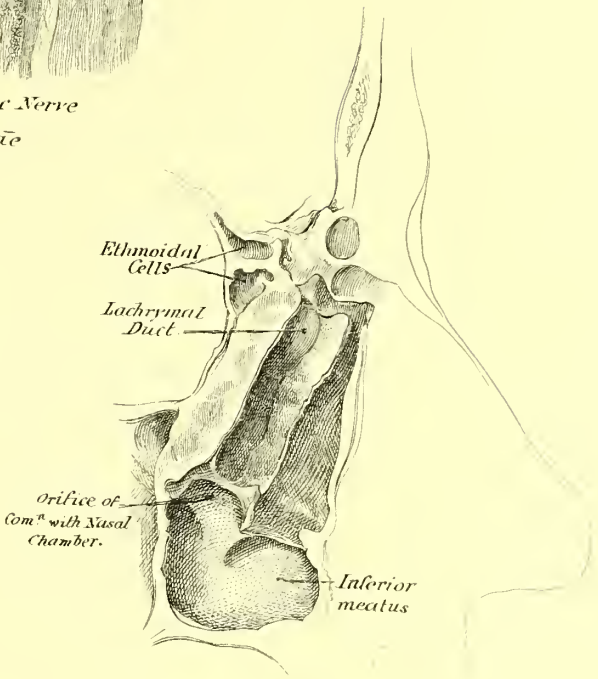


Fig 2

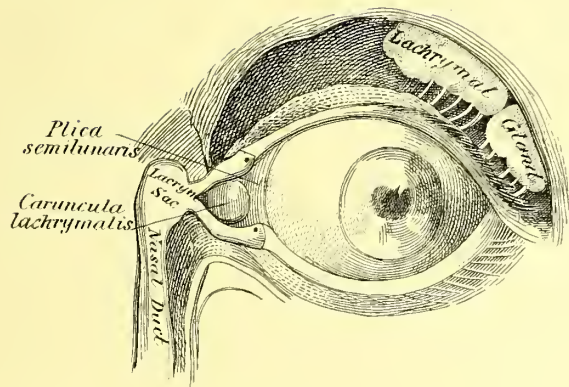


Fig 4

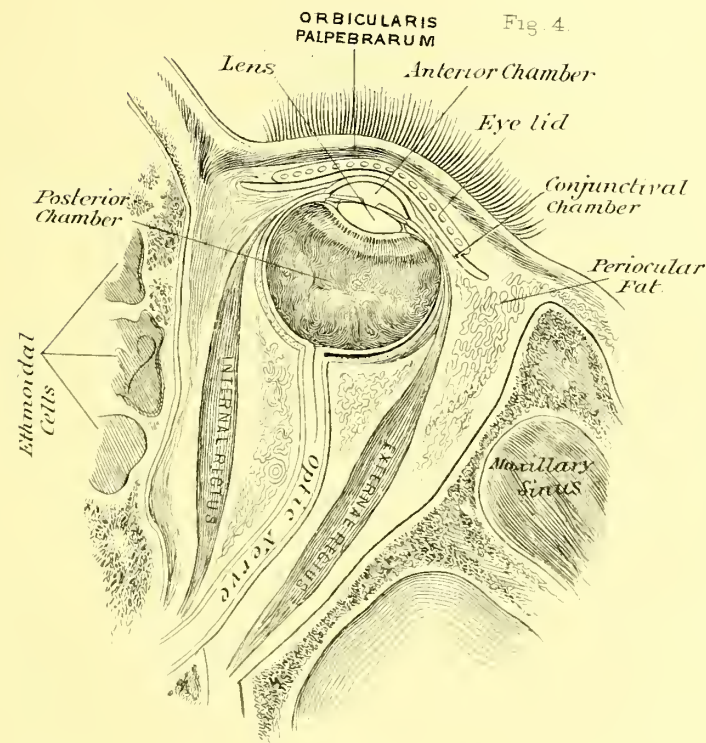
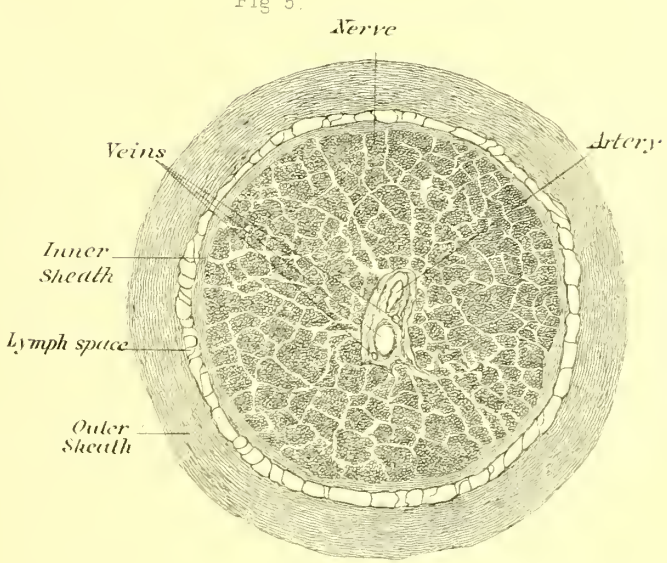
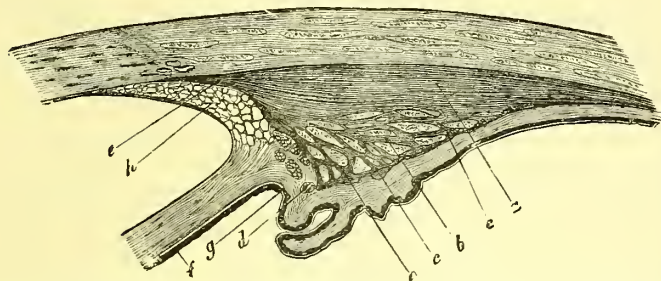


Fig 5



downward and to the inner side. The outer fixed margin (ciliary margin) of the iris is continuous with the choroid coat posteriorly, with the ciliary muscle

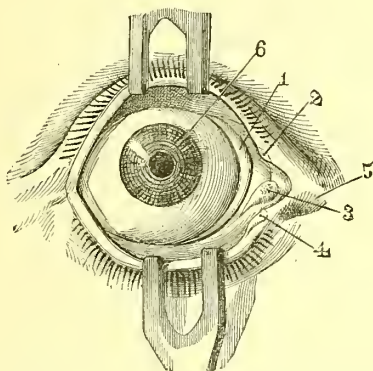
Fig. 133.



Section through the ciliary body and the corneo-scleral junction, showing the ciliary muscle, and system of spaces at the continuity of cornea and iris. *a*, choroid; *b*, radiating fibres of ciliary muscle—the small group of circular fibres are seen lying to the median side of the radiating; *c*, a transverse section of a bloodvessel; *d*, the uvea of iris; *e*, the pigment layer of the ciliary body; *f*, the spaces of Fontana (rendered too conspicuous).

externally, and with the peripheral fibres of the membrane of Descemet anteriorly.

Fig. 134.



The eyeball seen from in front, the eyelids being separated by lid-retractors. 1, semilunar fold; 2, 4, puncta; 3, caruncle; 5, internal palpebral ligament; 6, iris.

The *anterior surface* is variously colored, and marked, for the most part, with an open network of irregular, rounded spaces, having wavy borders. Near the pupil the markings are radial. The *posterior surface* (uvea of iris) is black.

The diameter of the pupil in health is, when contracted, about one-twentieth of an inch; when dilated, one-third of an inch.

Structure.—The iris exhibits three distinct layers:

(1) A layer of epithelial cells covers the front of the iris, which is continuous with the layer upon the posterior surface of the membrane of Descemet.

(2) The muscular layer gives form to the anterior surface of the iris, and presents two distinct divisions. The pupillary margin is surrounded by a well-defined continuous

muscle, one-fortieth of an inch wide, situated upon the posterior surface of the membrane, and called the contractor. The area between the circular layer and the margin is traversed by a number of radiate bundles, which, as they converge toward the pupil, occasionally anastomose at acute angles. They are inserted for the most part among the outermost of the fibres of the circular layers, a few reaching deeper. The interspaces between the muscular bundles are occupied by connective-tissue and pigmented cells, together with numerous bloodvessels and nerves.

(3) The uvea. The posterior surface of the iris is covered with a layer of black pigment-cells termed the uvea. This layer is continuous posteriorly with the similar layer constituting the pigment-layer of the retina.

Scattered throughout the iris are numbers of pigmented connective-tissue cells, black or of various shades of yellow and brown. These, with the pigmented cells of the uveal layer, are the agents which produce the coloration of the iris.

Pupillary membrane, or *membrana pupillaris*, is the name given to an embryonic structure which occupies the position of the future pupil. This membrane is vascular, its vessels being arranged in loops projected from the continuity of the membrane with the iris.

Bloodvessels.—The iris is an exceedingly vascular structure, being supplied by the terminal branches of the long ciliary, as well as by those of the anterior ciliary arteries, by branches of the lachrymal artery, and by muscular branches of the ophthalmic.

The *long ciliary arteries*, two in number, pierce the sclera on either side of the optic nerve, and pass forward between the sclerotic and choroid coats as far as the ciliary muscle, at which point they enter the iris. They anastomose at the outer margin of the membrane, forming a ring, the *circulus major*. Branches from this ring supply the ciliary muscle and the iris, the latter forming, by anastomosis, a second ring about the pupillary margin, the *circulus minor*.

The *anterior ciliary arteries* (short ciliary arteries) pierce the corneo-scleral junction, and supply the ciliary bodies. Their capillaries unite with these, and join the *circulus major*.

The *ciliary nerves*, twelve to fifteen in number, penetrate the sclerotic near the optic nerve, and pass forward in company with the long ciliary arteries. The nerves are, in the main, distributed to the ciliary muscle, within which they form a plexus, and from this the iris is supplied.

Variations.—A condition of congenital cleft or fissure in the choroid and iris has received the name of coloboma. The iris may be absent. The pupil may be placed eccentrically. In rare instances two pupils may be present in a

single iris.—The iris is subject to slight variation in its position. The portion of the iris resting on the lens lies a little in advance of the remaining portion of the iris, the exact degree of prominence being determined by the shape of the lens; thus it is less prominent in myopia than in hypermetropia.

REMARKS.—The choroid membrane, by reason of the slight attachment existing between it and the point of entrance of the optic nerve, as well as by reason of the powerful contraction of the ciliary muscle, is, as the result of long-sustained contraction of the muscle, pulled forward. Inspection of the interior of the eye with the ophthalmoscope will often exhibit crescentic figures of a white color outlined at the margin of the optic papilla, as the result of this forward traction exerted upon the choroid membrane. The white color represents the amount of exposure of the sclera, thus deprived of the choroidal lining. Ophthalmologists term these lesions the effects of "choroidal drag." They are typically expressed in neglected cases of hypermetropia.

The disposition of the choroidal vessels is believed by E. Jaeger¹ to hold a direct relation to the localization of the effects of malnutrition. Thus, the retina, as a consequence of the arrangement of the vessels in the choroid membrane, is liable to invasion by diseased action (such, for example, as the effects often seen in the eye from Bright's disease of the kidney); this action is localized in areas, which are limited by the subdivision of the choroidal vessels themselves. Jaeger defines these areas as follows: "One composed of the arterial circle of Zinn, which surrounds the optic papilla; another formed by the arteria centralis retinae, which supplies the retina; another composed of the short posterior ciliary arteries, which supply the posterior half of the choroid membrane; and still another composed of the long ciliary arteries, which supply the iris and the anterior half of the choroid membrane; the short anterior ciliary arteries also take part in the formation of this area."²

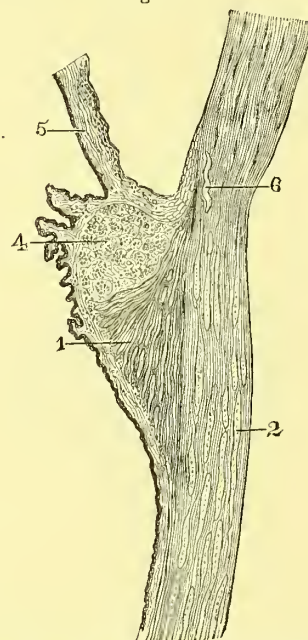
The iris, in clinical as in anatomical studies, may be considered as a specialized portion of the choroid membrane. It is a membranous sphincter, whose function is to determine the amount of light which enters the eyeball. The pupil is contracted in accommodation for near objects, and in sleep. Hence, the pain that follows attempts at inspection of minute

objects in irritated states of the iris, and the disposition to nocturnal exacerbations of pain in iritis. The pupil is dilated in accommodation for far objects.

A portion of the iris is excised in the operation for extraction of cataract, and for the arrest of glaucoma. It may by abnormal processes become adherent to the cornea, and be prolapsed by the effects of wounds, etc.

The ciliary muscle is devoted to the special work of modifying the shape of the crystalline lens (see account of the lens, p. 598). In extreme and long-sustained irritation, as in hypermetropia, numerous reflex characteristic symptoms arise. The muscle itself undergoes hypertrophy, as is represented in the accompanying sketch, fig. 135.

Fig. 135.



Section of the ciliary body, showing the hypertrophy of the circular fibres of the ciliary muscle in hypermetropia. 1, the radiate fibres of the ciliary muscle; 2, the sclera; 4, the circular fibres of the ciliary muscle; 5, the iris; 6, the canal of Schlemm.

In diminished traction of the ligament of the lens, as is noted in myopia, the muscle presents an appearance which is in marked contrast to that of hypermetropia, the circular fibres being rudimental or absent, as is seen in fig. 136.

THE RETINA.

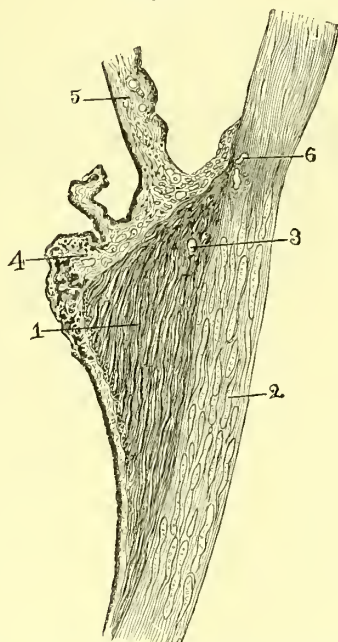
The Retina is the inner tunic of the eyeball, and immediately surrounds the vitreous body. It is a transparent membrane of a delicate pink color during life. It measures in thickness from the $\frac{1}{200}$ th of an inch anteriorly to the $\frac{1}{50}$ th of an inch posteriorly. The retina is in connection behind with the optic

¹ Ergebnisse der Untersuchung, mit dem Augenspiegel, etc., 1876, 16.

² A. G. Heyl, Med. News, 1884, xv. 327.

nerve, and at least one of its layers is prolonged from this structure. It is marked posteriorly at the point of entrance of the nerve by the optic disk, and in

Fig. 136.



Section of the ciliary muscle, showing absence of the circular fibres of the ciliary muscle in myopia. 1, the radiate fibres of the ciliary muscle; 2, the sclera; 3, the section of a vessel; 4, the ciliary processes; 5, the iris.

front by a number of radiate folds—the ora serrata. Between the ora serrata and the ciliary body is a thin membrane, the pars ciliaris retinae, which, according to Hyrtl, is continuous with the ciliary body and uvea. The optic disk is not in the axis of the organ, but lies a little to the inner side. At a point corresponding to the axis is a small oval spot, the macula lutea, which measures one-twentieth of a line in diameter.

Structure.—The retina is a membrane of great complexity. It is composed of eight layers, associated with a delicate framework termed the fibres of Müller. Counting from the inner or centric side, we recognize—

Internal limiting membrane.

1. The nerve-fibre layer.

2. The ganglionic layer.

3. The inner molecular layer.

4. The inner nuclear layer.

5. The outer molecular layer.

6. The outer nuclear layer.

(These constitute the “granular layer” of some authors.)

External limiting membrane.

7. The layer of rods and cones.

8. The pigment-layer.

(This constitutes the pigment-layer of the choroid coat of some authors.)

(1) The nerve-fibre layer is derived from the fibrils of the optic nerve. It is composed of non-medullated filaments having the thickness of brain fibres, which are arranged in flat wavy bundles directed forward. It is almost wanting at the macula lutea.

(2) The ganglionic layer consists of large ganglionic cells. The processes of the cells are so arranged that one unbranched filament commonly passes obliquely inward, and is lost within the nerve-layer. Others pass vertically outward and are lost within the inner molecular layer. The cells are most numerous at the macula lutea.

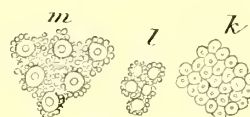
(3) The inner molecular layer is almost structureless. It is much thicker than the outer molecular layer, and is composed of numerous minute granular masses imbedded in a structureless matrix.

(4) The inner nuclear layer is made up of three to four rows of cells, whose nuclei are so large as to give the impression that they are free, but in each cell, a cell-wall can be detected, with cell contents at either end of the oval nucleus.

(5) The outer molecular layer (internuclear) resembles the inner of the same name, but is much thinner.

(6) The outer nuclear layer is distinguished from the inner by its association by continuity with the rods and cones, its cells fulfilling the function of axial supports. Those beneath the cones present a double contour-line on each, while the others, continuous with the rods, present a single contour line and are filamentous. The nuclei in this layer present a transversely banded appearance.

Fig. 137.



Portions of the layer of rods and cones seen from without. *k*, microscopic appearance of the outer surface of the retina over the yellow spot, where there are only cones; *l*, appearance of the retina near the yellow spot—a single circle of rods surrounding each cone; *m*, appearance of the middle of the retina, a large number of the rods surrounding each cone. In all three figures the larger rings represent the cones, and the smaller ones the rods seen endwise.

(7) The layer of rods and cones (Jacob's membrane, columnar layer) is the most highly specialized of the retinal layers. It is a remarkable group of slender columnar forms interspersed among sparsely distributed conical figures, which are shorter than the rods. The rods are absent over the macula lutea. The rods and cones are closely related structures. The basal portions are nearly structureless, but the apices are linearly striated, and those of the cones may present transverse markings. The layer is easily seen when the sclera and the choroid membrane from a fresh eye are immersed in cold water.

(8) The pigment-layer is a single layer of simple hexagonal cells, charged with black pigment-matter, whence delicate processes protrude between the rods and cones. The outer surfaces are flat. It lies in close contact with the

choroid membrane, with which it has been recently identified. The pigment-layer is evolved from the same primordial structures which yield the remaining retinal structures.

Variations.—In brunettes and negroes the quantity of pigment-cells is increased. In ophthalmoscopic examination of such subjects the eye-ground is dusky. In blondes and albinos the opposite conditions obtain, and the eye-ground, owing to the small quantity of pigment-cells, is of a delicate pink color.

The Fibres of Müller, known also as the sustentacular tissue, constitute the framework analogous to the connective-tissue stroma of other organs. By the apposition of the broad surface of their conical basal portions, an apparent continuous structure is formed—the so-called *membrana limitans interna*, situated within the layer of nerve-fibres. At the junction of the layer of rods and cones with the outer nuclear layer, the *membrana limitans externa* is similarly formed by the termination of the offsets of the framework. Some of the cells of the inner nuclear layer are seen as appendages to the fibres of Müller.

The macula lutea. The structure of the retina at this spot measures one-tenth of an inch. It is of a yellow color, due, it is thought, to a fluid (believed by Luschka to be of a fatty character) filling in the interior between the cones. About the centre of the macula is the pit-like depression called the *fovea centralis*. The cones alone are present over this spot, the rods being wanting, while the remaining layers here attain their greatest tenuity.

Bloodvessels.—The retinal vessels, according to Hyrtl, are derived from—

The artery of the sheath.

The artery between the neurilemma and medulla of the optic nerve.

The special central artery, which sends off loops upon the retina, and minute branches into the fovea centralis.

The blood reaches the layer of rods and cones, none going beyond the inner nuclear layer.

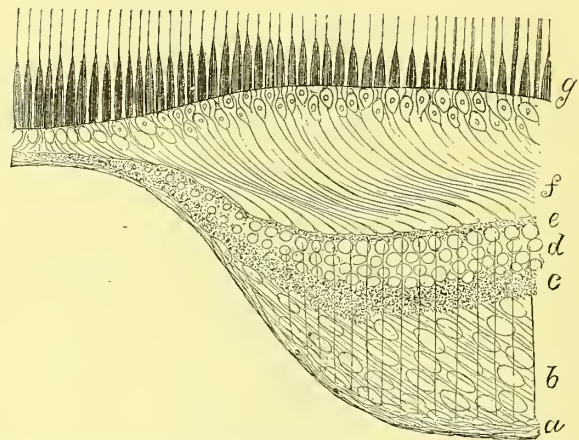
The “veins resemble capillaries in structure, their walls consisting of a single layer of epithelioid cells.” The structure of the ora serrata and pars ciliaris consists only of “elongated columnar cells with the pigmentary layer placed externally.”

The vessels, as seen by the ophthalmoscope in the living eye, present some distinctive features. Thus the veins of the “eye-ground” pulsate, while the arteries are without pulsation. The contours, both of the arteries and the veins, are imperfectly defined. The chief source of the images of both sets of vessels is the blood-currents themselves.

REMARKS.—The retina after death assumes a ground-glass or milky appearance. The macula lutea becomes inconspicuous, and a pair of transparent folds (*plica centralis*) is seen on either side of

the macula lutea, forming a pit-like depression—the fovea centralis, which, from the thinning of the retina at this point, permits the pigment-layer to become visible through it.

Fig. 138.



From a vertical section through the macula lutea and fovea centralis. *a*, Nerve-fibres; *b*, ganglion-cells; *c*, inner molecular layer; *d*, inner nuclei; *e*, outer molecular layer; *f*, cone-fibres; *g*, cones.

In addition to the remarks made under the head of the choroid membrane, it may be said that the retina may be detached from the choroid membrane over large surfaces. The retina is a favorite seat for gliomatous tumors.

THE VITREOUS BODY.

The Vitreous Body (vitreous humor) is a jelly-like, transparent structure occupying the posterior four-fifths or two-thirds of the eyeball, to the shape of which it conforms, except in front. Here the sides gently curve inward, forming a central dish-like depression for the lens.

The vitreous body is in direct contact with the retina, but is firmly held to the *pars ciliaris retinae*, and also to the ciliary body. This attachment constitutes the zone of Zinn (ciliary zone, suspensory ligament), and is of great importance, since it not only gives general support to the vitreous body, but yields points of attachment to the capsule of the lens. So intimate is this connection, that attempts at separation bring away with the vitreous body particles of the pigment-layer of the *pars ciliaris retinae*. When thus detached, the vitreous body is seen to be marked by a series of raised folds and intermediate depressions (ciliary portion of the vitreous body), answering to the processes of the ciliary body.

The limiting surface of the vitreous body is called the hyaloid membrane. It is smooth, of great deli-

eacy of structure, and differs from the interior of the vitreous body by becoming markedly differentiated in front, at the region of the attachment above mentioned. In the description of the termination of the hyaloid, it is usual to state that it divides opposite the ciliary body into two leaflets, one passing in front and the other behind the lens. But, while a continuity can be proved to exist between the hyaloid and the capsule of the lens, these structures are so peculiar that they deserve definition for the same reason that the iris is described separately from the choroid. In this way the hyaloid may be said to terminate in the zone of Zinn, the structure of this portion of the capsule of the lens deflected inward from the beginning of the zone, differing scarcely at all from the general features of the vitreous body. The zone of Zinn is distinctly fibrillated in a radial manner, very stout, and somewhat elastic. It measures three lines in diameter on the temporal side, and from two to three on the nasal. It is continuous in front with the suspensory ligament of the lens and the capsule.

Some authors describe all the structures between the hyaloid membrane and the capsule as the zone of Zinn, which thus presents a posterior fixed portion at the ciliary region and an anterior free portion corresponding to the suspensory ligament.

Structure.—The vitreous humor is composed of exquisitely delicate fibrils of a connective-tissue-like structure, having an arrangement as yet imperfectly understood. It is thought, however, that a radiate type of fasciculation can be detected extending from the periphery toward the centre, and surrounded by a clear, gelatinous fluid. That such a stroma is present can be shown by the fact that a film remains after filtering the fluid-contents, and that wounds of the vitreous body do not necessarily end in loss of all the fluid.

An occasional free nucleus can be seen as well as wandering leucocytes exhibiting amœboid movements. The hyaloid membrane is richly supplied upon its inner surface with tessellated corpuscles which may be looked upon as aggregated leucocytes. In the foetal state the vitreous body is perforated by the central artery of the retina.

The canal of Stilling is a passage the existence of which was for a long time in dispute. It is now, however, asserted by Schwalbe that a coloring matter can be injected through it by way of the pia mater sheath of the optic nerve.

REMARKS.—The vitreous humor can repair injuries to itself and losses of volume to a remarkable degree. The loss of small amounts of the vitreous humor is a frequent occurrence in the operation for cataract.—The chamber of the vitreous may be the seat of formations of cholesterine crystals and of connective-

tissue growths. Some varieties of *muscæ volitantes* are due to flakes of connective-tissue growths being tossed about in the chamber of the vitreous by the motions of the eyeballs. The vitreous humor may receive and encapsule minute foreign bodies. Its nutrition is dependent entirely upon the vessels of the choroid membrane, and, as a result, many if not all of its inflammatory conditions are accessories to primal states of the choroid membrane.

The canal of Petit. Between the suspensory ligament (zone of Zinn), the posterior capsule, and the lens is a delta-shaped space called the canal of Petit. Its walls are opposed during life, but can be inflated with air in dissection or in decomposition,¹ when a beaded appearance due to the lumen of the canal being narrower at short intervals is presented.

The tips of the ciliary processes lie free in the posterior chamber of the eye, over which passes a delicate structureless membrane which reaches to the ciliary border of the iris.

THE CRYSTALLINE LENS.

The Crystalline Lens is a biconvex, transparent structure situated between the vitreous humor and the iris. It is of a rounded form and inclosed within its own capsule, the anterior portion of which is thick and is continuous with the suspensory ligament. The posterior portion of the capsule is a thin layer of hyaloid membrane like that which lines the dish-like depression in the front of the vitreous body. At the side the rounded border of the lens forms the base of the delta shaped canal of Petit, whose remaining boundaries are defined by the layers of the suspensory ligament. The lens measures one-third of an inch (eight mm.) from side to side, and one-fifth of an inch from before backward. It is flatter in front than behind, and does not completely fill its capsule, a small quantity of a clear fluid being normally found therein, the so-called liquor of Morgagni.

Structure.—The lens is composed of an assemblage of lamellæ, which are developed from cells. Each measures $\frac{1}{5000}$ th inch in diameter, and presents a slightly serrated edge. Upon section it is observed to be 6-sided and prismatic. A lamella when examined in its formative stage is observed to be nucleated. These nuclei, however, early disappear or become inconspicuous, and can be demonstrated only by the action of reagents. The space between the lens and the anterior capsule is occupied by a single layer of nucleated cells.

¹ M. Aeby (Arch. f. Ophth., xxviii. 1882, 111) describes a method by which the canal of Petit can be studied with great advantage in an eye which has been subjected to maceration for several days in water.

The lamellæ are softer toward the periphery than at the centre of the lens; the latter part, from this fact, receiving the name of the *nucleus of the lens*. When the lens is macerated or hardened in chromic acid, there can be seen upon the anterior and posterior surfaces three lines or rays diverging from a central point, which divides the surface into three compartments, each compartment being composed of about one hundred and twenty lamellæ. The two surfaces do not correspond with respect to the position of these lines, those upon the anterior surface alternating with those upon the posterior. Thus the lines present a Y-shaped figure behind, while in front the Y is inverted, thus A. The lamellæ abut against the margin of these lines, and extending around the lateral margin, they assume a slightly wavy appearance.

Variations.—The lens in the child is more convex than in the adult, but is flattened in the aged.

REMARKS.—The lens in conditions of diseased action may become opaque, with various degrees of softening or hardening. The cortical portions of the lens may be soft, while the interior portions become hard. The lens, after the thirty-fifth year, becomes of firmer consistence than at any earlier period of life.

The degree of firmness of the lens holds a direct relation to age. The lens resists the influence of the ciliary muscle just in proportion as its parts become of firmer consistence and of diminished elasticity.

THE AQUEOUS HUMOR.

The Aqueous Humor is the clear watery fluid occupying the anterior and posterior chambers of the eye.

The Anterior Chamber.—The anterior chamber is the space between the cornea and the iris, being separated by the last-named structure from the posterior chamber, except at the pupillary orifice.

The Posterior Chamber.—The posterior chamber is the space between the iris and the anterior capsule of the lens. The ends of the ciliary process project slightly within this chamber. From the contact of the pupillary margin of the iris with the capsule, the two chambers do not communicate in the ordinary movements of the iris. When the pupil is widely dilated, however, the two chambers are thrown into one.

REMARKS.—The aqueous humor reaccumulates rapidly after loss as by a wound or by paracentesis. The chamber of the aqueous humor is the occasional seat of parasitic invasion, and may lodge a foreign

body. Pus when formed within the anterior chamber gravitates and forms a layer of pus at the bottom of the chamber, which has received the name of hypopion.

Variations.—Instances of persistent hyaloid artery are rarely met with. Dareste¹ has observed that in hernia cerebri, or in exencephala, and in cyclops, the eyeball is imperfectly formed, the lens and vitreous humor being notably defective.

The nerves of the retina are rarely provided with nerve-sheaths. When such sheaths are present, the appearance of the eye-ground is remarkably distinct from that of the normal eye, since the nerve-sheaths appear in the image of the ophthalmoscope as white opaque tracks along the course of the nerves.

THE EAR.

The Ear is the organ of hearing. It is divided into three portions as follows:—

The Outer Ear.

The Middle Ear.

The Internal Ear.

The Outer Ear comprises the auricle and the external auditory meatus.

The Middle Ear comprises the tympanic chamber with its contents and appendages. The contents of the tympanic chamber are the *ossicles*, the *malleus*, the *incus*, and the *stapes*, which form an association of bones connected externally with the *tympanic membrane*, and internally with the internal ear. The appendages of the middle ear comprise the mastoid cells and the Eustachian tube.

The Internal Ear includes the true organ of hearing and receives the *auditory nerve*. It communicates in the skeleton with the middle ear by two openings, the oval and the round window. In the undissected subject, the *oval window* is occupied by the base of the stapes and its annular ligament, and the *round window* by a membrane.

THE OUTER EAR.

The Outer Ear is composed of—

The Auricle.

The External Auditory Meatus.

The Auricle (pinna) is an appendage to the external auditory meatus which is designed for the reception of waves of sound. Its form is nearly elliptical, wider above than below, and is composed of an

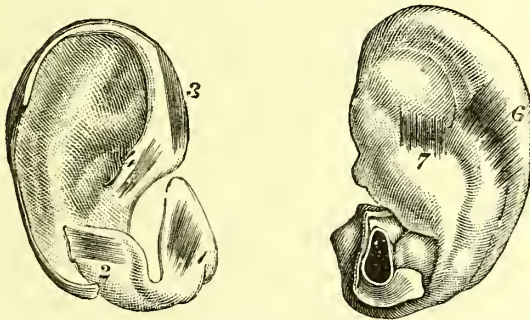
¹ Comptes Rendus, xcv. 44.

irregularly sculptured fibro-cartilage, connective tissue, muscles, and fat, the whole figure being covered with integument. The auricle in man is rudimental as compared with the same structure in many lower animals.

The *fibro-cartilage* gives form to the auricle, the lobe alone excepted. It is attached to the tympanic portion of the temporal bone, and its depressions and elevations correspond with those of the auricle as a whole.

The eminences on the anterior surface answer to depressions on the posterior surface, and *vice versa*. The features of the fibro-cartilage not seen from without are the *cauda heliis*, a tapering process of inconstant proportions which passes down into the base of the lobe of the ear, a small process answering to the external free margin known as the *process of the helix* (spine of the helix), and the various slits

Fig. 139.



The cartilage of the auricle. The figures 1, 2, 3, 4, 5, 6, 7 are placed on or near fascicles of muscle-fibres.

or fissures which are inconspicuous in the body of the cartilage, but which are well seen between the tragus and helix, and between the ring-like fissures of the concha (fissuræ Santorini) as it approaches the *pars tympanica*. The skin of the anterior surfaces of the auricle is held firmly to the perichondrium, in order to prevent an accumulation of fat from interfering with the reception of waves of sound. Fat is present in small quantity on the posterior surface of the auricle, where the skin is not firmly fixed to the perichondrium. In the ears of many healthy persons, well-defined folds of skin extend from the post-auricular space to the hinder surface of the auricle.

The following are the main points in the nomenclature of the external ear: An outer border termed the *helix*, beginning as a thin elevated central root sharply limited above and in front, but becoming more obscure along its outer border, and finally lost before reaching the lobe (fig. 1, Plate XCVII.).

Within the periphery of the helix is a second eminence—the *antihelix*. Starting below the root of the helix, the antihelix describes a shorter curve to terminate in two fork-like processes, the upper blunt, the lower sharp, which are lost behind the acute anterior border of the helix. The depression between the helix and antihelix is termed the *fossa of the helix*; that between the forks of the antihelix the *fossa of the antihelix*. The antihelix is continuous below with the *antitragus*, and thence through the line of the *intertragus notch* with the *tragus*.

The space between the antihelix, antitragus, and tragus is called the *concha*, and is crossed along its floor by the root of the helix.

Bloodvessels.—The *arteries* of the auricle are derived from the posterior auricular and temporal branches of the external carotid and at times from the occipital artery. The branch of the posterior auricular artery which passes to the front part of the auricle effects entrance from below through the fissure in the fibro-cartilage between the helix and concha.—The *veins* empty into the external jugular vein, though small venules join the temporo-maxillary vein.

The *nerves* of the auricle are derived from the superficial cervical plexus through the auricularis magnus, from the auricular branch of the trifacial, and posteriorly from the facial nerve. The auricular branch of the pneumogastric nerve, after giving a branch to the mucous membrane of the middle ear, also sends a branch to the auricle—a distribution in illustration of a fact often observed (see p. 461) that a nerve supplying a deep-seated region will be expected to send a second branch to the superficial parts of the same region. The point at which the nerve effects entrance into the temporal bone, namely, at the outer border of the jugular foramen through an opening near the styloid process, is also the region corresponding to the first visceral cleft of the embryo.—The exact areas of distribution of the above nerves can sometimes be determined in paralysis of the separate branches.

REMARKS.—Gruber¹ mentions a case in which the *cauda heliis* passed some distance into the lobe. It had been perforated in the procedure of piercing the ear. Severe inflammation of the auricle supervened, which extended to the retro-maxillary space, where an abscess formed.—The posterior surface of the auricle becomes swollen in erysipelas.

Ossifications of the cartilage are occasionally met

¹ Lehrbuch die Ohrenheilkunde, 1870, 1871.

with, not so much, however, as a result of advancing years as the effect, according to Garrod,¹ of gout. Toynbee² has seen similar deposits following atheroma in the insane.

A minute blunt point, variable in size and sometimes present on the ear of one side only, projects from the anterior margin of the helix. The process is worthy of notice, since in the judgment of Darwin³ it is the homologue of the structure composing the upward pointed extremity of the auricle in quadrupeds. Lucae⁴ ascribes the process to the effects of intra-uterine inflammation and pressure.

Variations.—The variations in the form of the auricle are numerous. The lobe, while as a rule pendulous, with a free anterior border, may occasionally be found confluent with the lines of the face and neck. In questions of identity the examination of the auricle may prove of value, and in many instances the form is hereditary. According to Gruber, a congenital deformity of the auricle has been observed in many generations.

The External Meatus (external auditory canal) (fig. 3, Plate XCVII.) extends from the auricle to the membrane of the tympanum. It is composed of two portions: the bony portion belonging to the pars tympanica of the temporal bone, and the cartilaginous portion belonging to the auricle. These two structures, while apparently continuous, are separated by a small irregular membranous space.

The direction of the meatus is sinuous, with an inclination slightly downward and forward. The union of the cartilaginous with the bony portion is marked by a ridge on the floor of the passage. That portion to the inner side of the ridge is directed downward, forward, and inward. That to the outer side of the ridge is directed downward, forward, and outward. The latter obliquity is better marked than the former. The canal may be made straight by traction of the auricle backward and slightly upward.

The entire length of the meatus ranges from nine to fifteen lines; of this, one-third the distance corresponds to the cartilage and two-thirds to the bone. The inclination of the antero-inferior surface of the wall, from the oblique position of the tympanic membrane, is downward and inward; the canal is widest at the junction of the cartilaginous and bony portions, the diameter ranging from two to five lines.

The bony meatus is in indirect clinical relation to the temporo-maxillary articulation. Hence, fractures

of the skull from blows upon the front of the lower jaw may include the tympanic bone. (See p. 124.)

The anterior part of the cartilaginous portion, being in relation with the parotid gland, may be involved by intumescence of that body.

Relations.—The boundaries and relations of the bony portion of the external meatus are best understood by recalling the fact that the anterior and inferior portions alone arise from the tympanic portion of the temporal bone, while the superior and posterior pertain to the squamous portion. Von Tröltsch has shown that the cavity of the middle ear extends both above and behind the external meatus at its tympanic end, and that in some individuals the distance between the meatus and the dura mater is so slight that extension of inflammation from the meatus to the membranes of the brain is possible.

At the entrance of the meatus the canal presents a subrounded opening, its shortest diameter being the antero-posterior. Within the canal is wider and slightly compressed from below upward. The floor is somewhat depressed in front of the tympanic membrane, where, according to Von Tröltsch, foreign bodies may become lodged.

Structure.—The meatus is lined with thin integument. This is perforated by the orifices of numerous minute glands (ceruminous glands) which secrete a waxy substance. These glands are most numerous within the inner half of the cartilaginous portion of the canal, although a few can be traced as far as the membrane itself. They belong to the convolute type, and are lodged in the subdermic connective tissue. Some of them are sufficiently large to be received in corresponding depressions in the cartilage.

Bloodvessels.—The arteries are derived from the posterior auricular branch of the facial, and from the deep auricular branch of the internal maxillary which supplies the tragus.

REMARKS.—In children the tympanic membrane is nearly horizontal.—Pus from the parotid gland may open into the meatus.—In aged edentulous individuals the condyle of the lower jaw may press against the cartilaginous portion of the meatus and induce deafness.—Owing to the curved direction of the meatus, perforations of the tympanic membrane along the lower portion may escape notice.

THE TYMPANIC MEMBRANE.

The Tympanic Membrane (membrane of the drum) is a subrounded partition between the external meatus and the chamber of the tympanum. It is firmly lodged in the groove of the tympanic bone by the aid of a circle of fibrous tissues known as the *annulus tendinosus*.

The tympanic membrane measures from four and a half to five lines in its longest or vertical diameter, and four in its shortest.

¹ Nature and Treatment of Gout, 1859.

² Trans. Path. Soc. Lond., 1860, xi. 225.

³ Descent of Man, 1871, 22.

⁴ Virchow's Archiv, xxix. 6, 2.

A description of the tympanic membrane embraces—

- (1) The layers of which the membrane is composed.
- (2) The topography of the outer surface.
- (3) The topography of the inner surface.

(1) *The layers of which the membrane is composed.* The tympanic membrane is composed of three layers: the outer, the middle, and the inner.

The *outer layer* (dermoid layer) is epithelial in character, and is continuous with the skin of the external meatus. In macerated specimens of the ear, the skin of the meatus can be removed as the finger of a glove from the finger.

The *middle layer* (fibrous layer, *membrana propria*) is composed of two layers of fibres: the outer or radiate, and the inner or circular layer. The radiate fibres are stouter than the circular, and are attached to the tympanic bone, converging thence to the centre of the membrane. The circular fibres are weaker toward the centre than elsewhere. Many of them originate upon the membrane, having no extrinsic attachment. Interspersed through the membrane are other fibres which do not demand detailed description.

The *inner layer* (mucoid layer) is thin, and is covered with a tessellated epithelium, continuous with that of the middle ear. Brücke¹ states that the epithelial cells are at times ciliated like those through the rest of the tympanic chamber. Villus-like projections have been found by several observers² attached to this surface of the membrane.

The handle of the malleus is attached to the membrane by a special mechanism. It lies in a groove of hyaline cartilage, which is converted into a canal at the base of the handle, and invests the short process. Some degree of motion probably obtains between the manubrium and its curious groove-like sheath. The handle and short process of the malleus modify the shapes of the two surfaces, and serve as the basis of their topography.

(2) *The topography of the outer surface.* When the tympanic membrane is examined through the external meatus (fig. 4, Plate XCVII.), it is seen to be inclined downward and inward, with a slight inclination forward. Thus it is seen to be deeper below and in front than above and behind, while the inferior and anterior part is on a deeper plane than the superior and posterior.

The handle is distinctly seen upon the surface as a long scythe-shaped process directed obliquely downward and backward, and terminating a little below the centre of the membrane. Above the handle and nearly in a line with it is the short conical process of the malleus. Passing backward from the short process to the posterior margin of the membrane, is the *posterior tympanic fold*. Extending forward from the same point or origin to the anterior margin is a second shorter fold, the *anterior tympanic fold*.

The short process and the two tympanic folds form a line which serves to separate the two divisions of the outer surface of the tympanic membrane.

The surface below the line is of a grayish pearl tint with a slight yellowish admixture. It is depressed at the apex of the manubrium to form the *umbo*. Between the umbo and the margins the surface is drawn inward, making the membrane assume a funnel-shaped figure, the sides of which are remarkable for presenting convex surfaces outward. Since the light falls upon that portion of the membrane which reflects the rays most nearly at a right angle, a triangular cone of light (pyramid of light) is seen to extend downward and forward with its apex at the centre of the umbo. The semi-transparency of this portion of the membrane permits the long process of the incus and the stapes to be occasionally seen. The transmission of the outline of the promontory is also possible.

The smaller region above the line of the short process and tympanic fold is of a uniform reddish color, and is not translucent. The tympanic membrane is here thinner than elsewhere, and is covered by a membrane, ordinarily not distinguished except by dissection, termed the *membrane of Shrapnell* (*membrana flaccida*).

The outer surface of the membrane is also divided into quadrants. This is an inexact method, but has been found convenient. If a line produced along the axis of the manubrium be cut by one drawn through the end of the same process from before backward, unequal quadration of the membrane results. Those portions behind the first line are termed the posterior quadrants, and those in front the anterior quadrants. These are again divided by the line drawn from before backward in such wise that there are defined an antero-superior and a postero-superior quadrant as well as an antero-inferior and postero-inferior quadrant. Each of these portions is again divided into a superior and an inferior.

¹ Physiologie, ii. 215.

² Gruber, Studien über das Trommelfell, 20.

(3) *The topography of the inner surface.* The inner surface of the tympanic membrane is *convex*. It is marked by two folds which form the boundaries of the pockets of Von Tröltsch. The *anterior pocket* is a depression between the base of the long process and the neck of the malleus, the anterior malleolar ligament, and the fold of mucous membrane answering to the chorda tympani nerve. The *posterior pocket* is open below, and is situated at the posterior superior part of the membrane, and is formed by a fold of membrane running toward the handle of the malleus.

A third pocket or pouch is described by Prussak and Brunner. This cavity, according to C. Burnett,¹ is defined behind by the neck of the malleus, below by the upper surface of the short process, in front by the membrana flaccida, and above by the external malleolar ligament.

REMARKS.—Since the action of the Tensor Tympani muscle is to rotate the malleus and to make tense the tympanic membrane, it will be seen that the effects of such rotation should be carefully studied as the membrane is exposed at the bottom of the external auditory meatus. The anterior quadrants are deepened; the handle of the malleus is retracted and appears foreshortened, its narrowest edge presents itself toward the membrane, while the free end of the process is rounded and thickened. These characters when taken together are pathognomonic of increased inward tension and retraction of the membrane, and are of great value to the physician in studying this condition as a correlative of chronic aural catarrh.

Lucæ² has observed a movement of the membrane in respiration.

The rare appearance upon the outer surface of the membrane of the apparent duplication of the short process is explained as follows: the process has

slipped out of its sheath, the process counting for one eminence, the sheath for the other.

The membrana flaccida is often the seat of acute changes, in which the rest of the tympanic membrane does not participate. On the other hand, congestive, particularly catarrhal, conditions are apt to be announced by increased redness and lividity of this membrane. The student, therefore, should make himself familiar with its normal appearances in the living subject.—The membrana flaccida is sometimes greatly relaxed, and individuals have the power by inflating the middle ear to cause it to bulge outward. This condition is not of necessity associated with any diminution of hearing.

The third pouch may become filled with mucus or pus, and it may be, in consequence, ruptured. Many cases of earache, which present no features of distension of the drum-head proper, or, in fact, of the region of the membrana flaccida, may be relieved instantly by puncturing the latter at the third pouch. The point to be selected for the puncture lies just above and in front of the short process.

Variations.—The plane of the tympanic membrane varies with respect to the axis of the external meatus. In children the inclination from above downward is more oblique than in the adult. In some adults the membrane is inclined forward and inward.—The membrane of Shrapnell is an exceedingly variable portion of the tympanic membrane. It is often perforated by an exceedingly minute canal situated close to the short process, and called the *foramen of Rivini*. In the opinion of some writers, the membrane of Shrapnell is closed in health—the opening being the result of morbid action or of imperfect development.—Numerous minute variations in the details of the membrane both in structure and color are to be detected, which have received little or no attention.

THE TYMPANIC CHAMBER.

The Tympanic Chamber is a narrow, irregular space between the outer wall of the labyrinth and

¹ Treatise on Diseases of the Ear, 82.

² Archiv für Ohrenheilkunde, 1864, i. 96.

EXPLANATION OF PLATE XCVII.

Fig. 1. The auricle.

Fig. 2. The temporal bone, showing the chamber of the tympanum displayed from within, and the malleus and incus as well as the Eustachian tube in position.

Fig. 3. A frontal (vertical transverse) section of the chamber of the tympanum and the bottom of the external auditory meatus.

Fig. 4. The tympanic membrane, seen in position at the bottom of the external auditory meatus. The membrane is divided into fourths by two dotted lines crossing each other at the position of the umbo.

Fig. 5. The temporal bone so divided as to display the inner wall of the tympanic chamber.

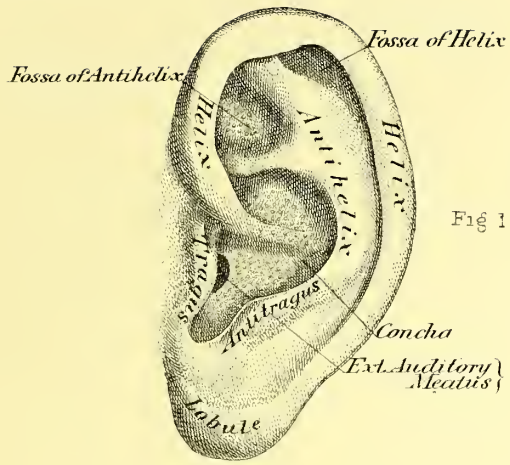


Fig. 1

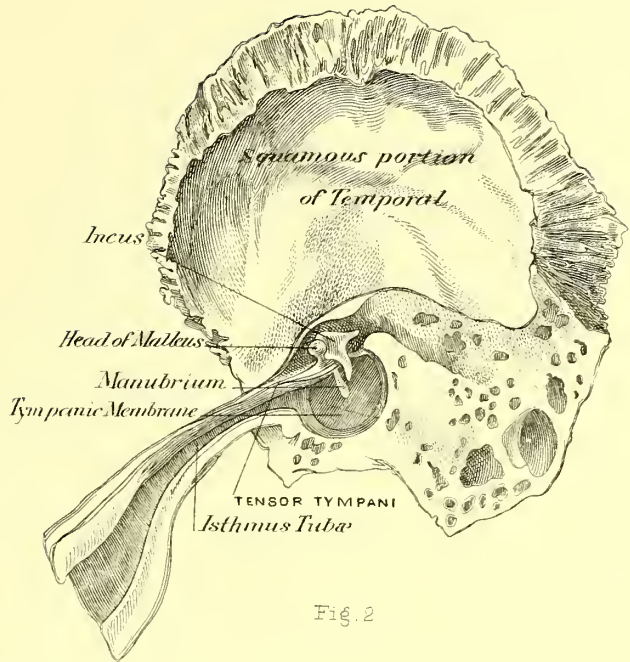


Fig. 2

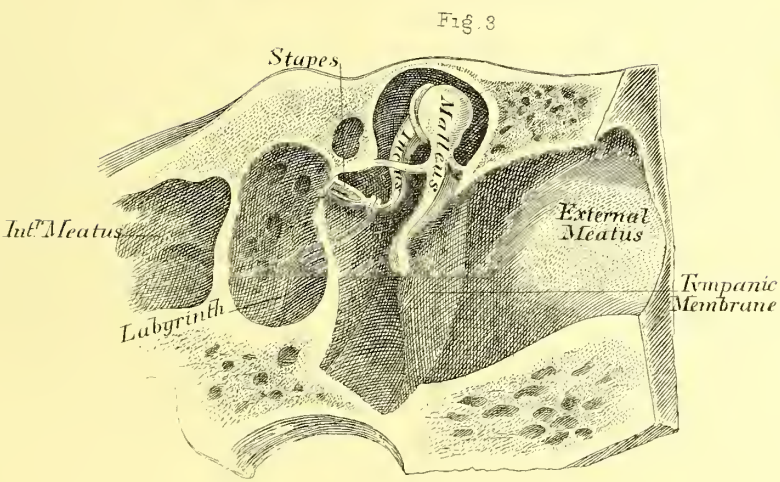


Fig. 3

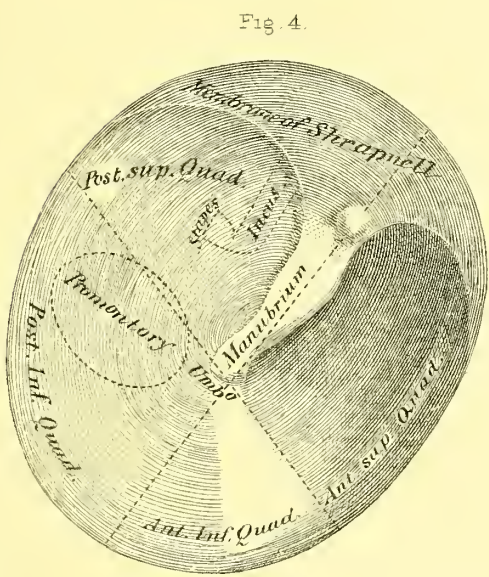


Fig. 4

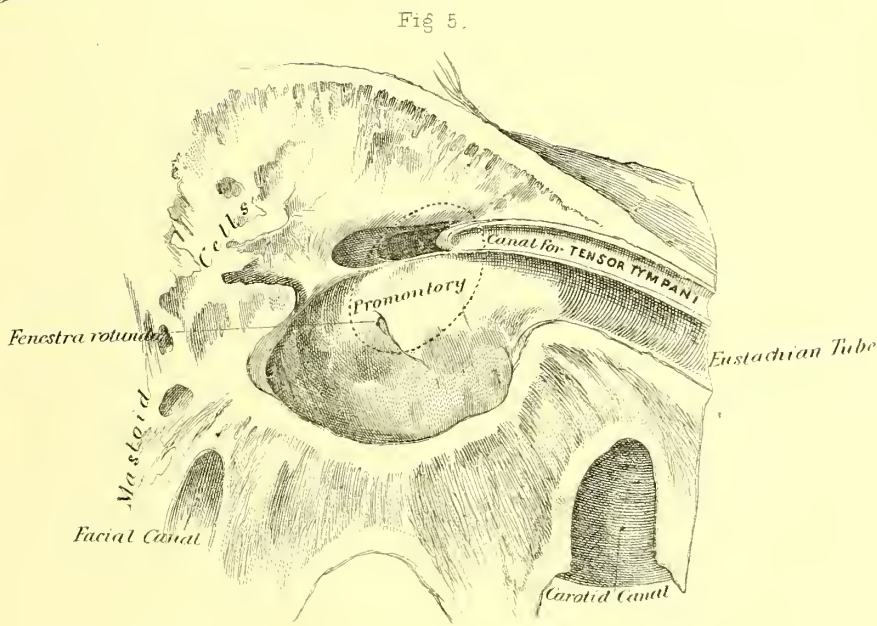


Fig. 5

the tympanic ring and membrane. It communicates in front with the Eustachian tube, and behind with the mastoid cells.

It is filled with air through the Eustachian tube, is lined with mucous membrane, and contains the ossicles.

The chamber is four and a half lines high, two lines in its greatest diameter, and one-twentieth of a line in its smallest, *i. e.*, between the umbo and the promontory. For convenience in description six sides are recognized: an inner and an outer, a superior and an inferior, an anterior and a posterior.

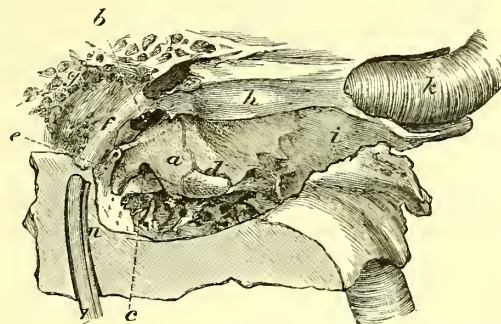
The inner wall.—The inner wall (labyrinthine wall), fig. 140 (fig. 5, Plate XCVII.), is osseous, and answers in great part to the outer wall of the labyrinth. Its most conspicuous feature is the *promontory*, a rounded, irregular eminence, lying between the oval and round windows, and overlooking the latter. It is caused by a projection outward of the basal turns of the cochlea. Above the promontory is a reniform opening, lying in a shallow depression parallel to the tympanic membrane. It is called the *oval window*, and is occupied by the base of the stirrup. Below this, and concealed from view at the meatus, is a smaller rounded opening, the *round window*, which is occupied by a membrane (the secondary tympanic membrane). The oval window communicates with the cavity of the vestibule, the round window with the scala tympani of the cochlea.—Extending backward and then downward, is a ridge-like swelling which is the outer wall of the *canal for the facial nerve* (aquæductus Fallopii). Its walls are thin, and inflammation may extend by continuity of structure directly from the middle ear to the facial nerve.—As an appendage to this descending portion of the canal is a small hollow process directed upward, known as the *pyramid*. It gives origin to the Stapedius muscle.—In front of the promontory is the beginning of the *tube for the Tensor Tympani muscle* (semicanalis). This is six lines long, and extends forward and downward toward the orifice of the Eustachian tube.

Under the tube for the Tensor Tympani, Luschka calls attention to a small portion of the carotid canal, which is here so thin at times as to permit, through ulcerative process, the occurrence of hemorrhage into the middle ear.—Von Trötsch describes a point between the oval window and the facial canal, which answers to the horizontal semicircular canal.

The outer wall.—The outer wall is smaller than the inner, and is, except at the position of the tympanic membrane, occupied by the thin margin of the tym-

panic ring and the squama. In front is the glenoid fissure, which receives the slender process of the malleus and the anterior malleal ligament. Near this again is the minute opening, known as the canal of Huguier, for the chorda tympani nerve.

Fig. 140.



A diagrammatic representation of the inner wall of the tympanic chamber. *a*, promontory; *b*, oval window; *c*, round window; *d*, nerve-grooves on the promontory; *e*, pyramid; *f*, prominence of aqueduct of Fallopius; *g*, openings of mastoid cells; *h*, tube of tensor tympani; *i*, osseous part of Eustachian tube; *k*, internal carotid artery; *l*, facial nerve.

The upper wall.—The upper wall (tegmen tympani) is thin, and is derived from the petrous portion of the temporal bone. It is frequently perforated by one or more minute openings. The lining membrane of the chamber comes in contact with the dura mater of the middle cerebral fossa at these points.

The lower wall.—The lower wall, the result of the convergence of the outer and inner walls, is but little else than a groove, and answers in position to the jugular fossa. Rarely the floor, like the roof, is defective.

The posterior wall.—The posterior wall is roughened. At its upper portion it presents an opening for communication with the mastoid cells.

The anterior wall.—The anterior wall is narrow, and, like the preceding, is incomplete. The Eustachian tube begins at its junction with the inner surface. A short distance above this opening is the position of the grooved canal for the Tensor Tympani muscle.

The tympanum is supplied by the tympanic or Jacobson's nerve, and by branches from the otic ganglion of the fifth nerve.

The mucous membrane is thin, delicate, and firmly associated with the bones. For the most part the epithelium is tessellated, but may be ciliated.

Bloodvessels.—The *arteries* are derived from a branch of the internal maxillary and the stylo-mastoid branch of the posterior auricular, which goes to the posterior part of the cavities and to the mastoid cells; a small twig supplies the malleus; a twig from the middle meningeal passes through the roof of the

chamber. The *veins* are tributary to the temporal vein in great part. The middle meningeal and pharyngeal veins, however, receive some of the blood. Two minute veins run parallel to the manubrium.

REMARKS.—The internal carotid artery may ulcerate into the middle ear through a carious condition of the carotid canal, and fatal hemorrhage ensue.¹ Toynbee² describes a case of the same lesion in which death followed on the eleventh day after the first appearance of the hemorrhage.

The floor of the middle ear is contiguous with the internal jugular vein. In consequence of the extreme variability of the thickness of this floor, it should always be borne in mind, in clinical studies of the ear, that inflammation in the tympanic chamber can be transmitted to the internal jugular vein. The lateral sinus may be involved by the encroachment of diseased action to the sigmoid groove through the walls of the mastoid cells.

The tegmen tympani or roof of the tympanum, while at all times thin, is, as above mentioned, often incomplete. Hyrtl has especially described these defects, and has directed attention to the contiguity of the dura mater and mucous membrane at such points. The student is cautioned against confounding these openings with the lesions of caries. It has been suggested by Gruber,³ that forced inflation of the middle ear in the condition just named actually may induce submeningeal emphysema.

In the fœtus the cavity of the tympanum contains no air. The mucous membrane is thick, especially that upon the inner wall, and extends like a thick cushion to the smooth inner surface of the tympanic membrane. It is in every way probable that the band-like processes described by Urbantschitsch⁴ as passing from the vertical and horizontal limbs of the incus to the walls of the tympanum, as well as one which stretches from the tendon of the Tensor Tympani to the tympanic wall, are remains of this pre-natal connective tissue. In dissection of the ear, more particularly, care should be taken to distinguish these structures from morbid products.

The non-compact character of the osseous tissue to the outer side of the head of the malleus enables abscesses, originating in the tympanic chamber, to develop in the upper part of the meatus, and involve the outer ear without giving signs of their presence by any change in the tympanic membrane.

Several cases have been recorded in which caries involved the horizontal semicircular canal, so that products of inflammation passed out of the cavity of the tympanum into the vestibule, and thence by the cribiform bony lamellæ to the internal auditory meatus. Pus may also enter the labyrinth by the oval or by the round window in destructive inflammation of the tympanic cavity.

Perhaps the most frequent of all the lesions of the middle ear, creating disturbance in venous, arterial, or nerve-trunks in its immediate neighborhood, is that of the involvement of the tympanic wall of the facial canal. Many phases of facial palsy follow interference with this passage and its contents through aural catarrh and necrosis. (See also Facial Nerve, p. 532.)

The quantity of mucus normally present in the middle ear is very small. It doubtless tends to gravitate to the floor, and there accumulates until it can reach the level of the orifice of the Eustachian tube, when it insensibly drains into the pharynx. After death the groove in the floor of the Eustachian tube is thus found occupied with mucus and desquamated ciliated epithelial cells. When the mucus is abnormally abundant, it obliterates the chamber of the tympanum as an air-chamber. Its physiological value being thus destroyed, morbid sensations of a variety of kinds follow. If the fluid be evacuated, as usually occurs by rupture of the tympanic membrane, the normal functions of the parts are restored. But if any portion of it remains at a higher level than the orifice of the Eustachian tube, the ossicles become impeded in their action, and in the event of the mucus becoming inspissated upon them, deafness may ensue.—The motions of an abnormal quantity of mucus in the tympanic chamber, dependent on inflation of the chamber, may be studied in cases of unusually translucent membranes.

In some cases of suspected fracture of the base of the skull, in which escape of a serous fluid from the middle ear was conspicuous, Prescott Hewett¹ ascertained that the fluid did not come from the membranes of the brain, but was doubtless derived from the mucous lining of the middle ear. Such cases tend to show not only that the presence of such a sign is not necessarily characteristic of fracture, but that the mucous membrane of the middle ear is capable of throwing off under certain conditions large quantities of a watery fluid.

¹ N. Y. Med. Journ., 1874, xix. 38.

² Med. Chir. Trans., xliii. 217.

³ Oestr. Zeitsch. für Prakt. Heilkunde, 1864, 54.

⁴ Urbantschitsch, Roy. Acad. of Sci., Vienna, Jan. 1873.

¹ Holmes's Syst. of Surg., ii. 133; also H. Gray, Trans. Path. Soc. Lond., vi. 22.

THE MASTOID CELLS.

The Mastoid Cells are irregular interspaces in the mastoid portion of the temporal bone, communicating with the cavity of the tympanum. They form two sets; an upper or horizontal, and a lower and more irregular set. The upper are constant at all ages, but the lower are dependent upon the development of the mastoid process. Both are lined with a thin muco-periosteum, bearing flat epithelium cells, and are without glands.

Not infrequently the inner wall of the mastoid portion of the temporal bone is deficient at one or more places of small extent, corresponding to the situation of the floor of the lateral sinus, thus permitting the dura mater and mucous lining of the mastoid cells to come in contact.

REMARKS.—The great ease with which inflammation of the middle ear may in some cases extend to the membrane of the brain is explained by the direct relation of the structures.

In the same way attenuation or other impairment of the outer wall of the mastoid portion will often cause emphysema of the submeningeal connective tissue, to follow slight injury.¹

It is highly probable that the venous hemorrhage, which sometimes occurs from the outer ear, after blows upon the occiput, comes from the lateral sinus, and reaches the middle ear by fracture of the bone about the mastoid cells.

THE EUSTACHIAN TUBE.

The Eustachian Tube (figs. 2 and 5, Plate XCVII., fig. 4, Plate XCVIII.) is the passage between the pharynx and the tympanic chamber. It passes outward and a little upward and backward, and measures from eighteen to twenty lines in length. The tube is divided into two portions: the osseous and the cartilaginous. The line of junction of the two portions is slightly angulated.—The *osseous portion* is inclosed between the pars tympanica in front, the anterior wall of the carotid canal behind, and the *teymen tympani* and the groove for the Tensor Tympani muscle above. It is fourteen lines in length, two lines in diameter, and represents one-fourth to one-third the entire length of the tube. It begins by a sub-elliptical orifice at the antero-inferior portion of the tympanic chamber, and terminates abruptly in a spinous process opposite to or a little in advance of the spinous process of the sphenoid bone.—The *membranous portion*

is about an inch in length, and lies in a groove formed between the anterior wall of the carotid canal on the one side, and the posterior border of the horizontal portion of the great wing of the sphenoid bone on the other. Between these two portions is the sphenoido-petrosal fissure. The groove terminates opposite the posterior free edge of the inner plate of the pterygoid process. The membranous portion is held in position by dense fibrous tissue, which is continuous with that lying in the sphenoido-petrosal fissure and elsewhere at the base of the skull.¹ The essential feature in this portion of the tube is its *cartilage*. This is a sub-involuted plate (tubal cartilage), composed for the most part of pure hyaline cartilage. It is narrow at its junction with the bony portion, but gradually increases in size toward the pharyngeal end. The cartilaginous portion is from this peculiarity much wider toward the pharynx than toward the tympanum, and has received the name of the *salpinx* or *trumpet*. At its tympanic extremity, the cartilage lies for the most part upon the sphenoidal side of the groove, but through the greater portion of its course it is related to the carotid side. It is curved above to form the roof of the passage, and is thence abruptly deflected a short distance along the sphenoidal side, where it terminates. From this fact the cartilage is often called the *hook cartilage*. The floor of the tube and the remaining portion of the sphenoidal boundary are membranous. They are, however, strengthened at the pharyngeal end by the Tensor Palati and Levator Palati muscles. From the intimate relation of the above muscles with the tube, Rüdinger proposes to call this the *muscular portion*.

Occasionally the rounded end of the inferior turbinated bone extends to the opening of the tube so as to cover it. In the child the tube is horizontal, the osseous part is comparatively long, the isthmus small, and the pharyngeal orifice large.

The *mucous membrane of the tube* is separated from the cartilage by a thin layer of connective tissue, which gradually becomes thicker toward the pharynx. The tube is almost completely without glands toward the tympanic end, but is thick, cushiony, and richly supplied with racemose glands toward the pharyngeal end. The epithelium is throughout ciliated, and the movements of the cilia are so directed that the tendency is from the tympanic chamber toward the

¹ Hyrtl, Sitzungsberichte der Kais. Akad., 1858, 252.

¹ The tube may be described as having a tympanic (*i. e.*, outer), a pharyngeal (inner), a carotid (posterior), and a sphenoidal (anterior) portion.

pharynx. At the muscular portion of the tube one or two foliated elevations are found which project into the canal. These are best seen in transverse sections studied under low powers of the microscope.

The osseous and cartilaginous portions of the tube, when at rest, exhibit a marked difference in the shape of the lumen. The bony portion is subrounded and fixed, while the cartilaginous is slit-like, and its cross section has a sigmoid form with the sides almost contiguous. The height of the pharyngeal orifice is about three and a half lines (Henle). The slightly contracted portion between the cartilaginous and osseous portions is called the *isthmus* of the Eustachian tube, and measures but one line in diameter. According to Dr. E. Cutter,¹ the isthmus may be absent in the aged.

Bloodvessels.—Twigs are received from the ascending pharyngeal artery, as well as a petrosal branch of the middle meningeal. A small twig also comes from the stylo-mastoid artery.

Nerves.—These are derived from the fifth and seventh cranial nerves, and from the glosso-pharyngeal nerve through a twig from its tympanic branch.

A lymphatic network is found at the pharyngeal orifice which is continuous with the lymphatic system of the naso-pharynx.

The lower end of the hook cartilage lying at the floor of the bony sulcus is more or less irregularly incised. Vascular tufts of peri-chondrial connective tissue may penetrate the substance of the cartilage here and there.

Structure.—While the cartilage is of the hyaline variety, examples of fibro-cartilaginous tissue are met with at various places, especially in the neighborhood of the borders.

The pharyngeal orifice of the Eustachian tube is commonly at the upper and outer part of the posterior nares. It may, however, be opposite the middle and sometimes even the lower part.

The Eustachian tube is probably open at all times; that is to say, air can effect entrance through the upper portion of the lumen of the Eustachian tube, even when it is at rest. The degree of patulency of the pharyngeal end is determined by the Levator Palati, Tensor Palati, and Palati-Pharyngeus museles. (See p. 259.)

The value of the position of the isthmus to the physician is made evident when it is remembered how small a quantity of mucus would be sufficient to plug up the opening. Upon such obstructions ensue disturbances of hearing, noises in the ear, etc.

THE OSSICLES.

The Ossicles (ossiculi auditis) (figs. 2 and 3, Plate XCVII., fig. 4, Plate XCVIII.) constitute the chain of little bones which extend across the middle ear.

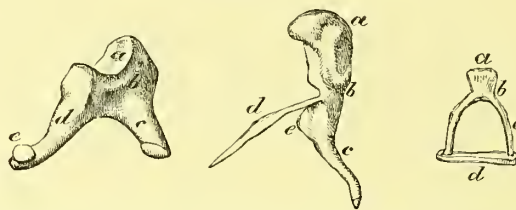
The ossicles are three in number—

The Malleus.

The Incus.

The Stapes.

Fig. 141.



The three Ossicles of the Tympanum: the central bone is the Malleus, the left-hand bone the Incus, and the right-hand bone the Stapes.

Malleus: *a*, head; *b*, neck; *c*, handle; *d*, long, and *e*, short process. Incus: *a*, head; *b*, body; *c*, upper process; *d*, lower process; *e*, lenticular process. Stapes: *a*, head; *b*, neck; *c*, crus, *d*, base.

THE MALLEUS. The Malleus (the hammer or the mallet) is the most anterior and exterior of the ossicles. It lies between the tympanic membrane and the incus. It is of a club-shaped figure, the larger end being upward. The bone presents for examination a *head*, a *neck*, a *handle*, and two *processes*. The *head* is a smooth rounded enlargement of the bone, which is lodged in the upper portion of the chamber of the middle ear. It lies entirely above the tympanic membrane, and constitutes nearly one-half of the entire malleus. The head is convex in form, and is free from attachment on all its surfaces excepting above the lower half of the inner surface, which is furnished with an elliptical articular facet for the body of the incus. The facet is two or three times as long as it is wide, has its longest length obliquely placed to the axis of the malleus, and is furnished with swollen borders.

The *neck* is a constricted portion of the malleus, which lies between the head and the handle. It is somewhat flattened from within outward, and lies just above the upper margin of the tympanic membrane. The chorda tympani lies to its inner side.

The *handle* (manubrium) is a scythe-like extension of the malleus. It maintains a direction downward, with a slight inclination inward and forward. The handle is compressed from before backward, except toward the free end, where it is compressed from within outward. It is received within the middle layer of the tympanic membrane, and causes an elevation to appear upon the outer surface of the mem-

¹ Am. Journ. Med. Sci., April, 1872, p. 359.

branch, which forms with the short process a conspicuous feature at the bottom of the external auditory meatus.

The *processes of the malleus* are two in number, the *long* and the *short*. The *long process* (process of Foli) arises from the base of the handle at its anterior aspect. It is directed at first forward, and afterwards downward and forward as a thin, flat pointed blade which is finally received within the glenoid fissure. The *short process* is a small but conspicuous projection from the anterior aspect of the base of the handle. It is directed outward, and is engaged in the tympanic membrane, where it forms a whitish elevation already described.

The long process represents the primordial axis of the malleus, and in the fœtus is continuous with Meckel's cartilage. In childhood it lies free in the glenoid fissure, but is liable to be mutilated in specimens obtained from adult subjects from its disposition to become ankylosed to the sides of the fissure.

THE INCUS. The Incus (anvil) is situated in the chain of ossicles between the malleus and the stapes. It is composed of a body and two processes. The whole figure bears a resemblance to a bicuspid tooth—the body corresponding to the crown of the tooth, and the processes to the diverging roots. The body and the upper of the two processes lie above the upper margin of the tympanic membrane. The *body* is compressed from within outward, and gradually diminishes in volume from before backward. It presents in front a subrounded saddle-shaped facet for articulation with the malleus. The *upper process* (short, posterior, or horizontal process) is nearly horizontal, and is directed backward. The upper border is inclined, while the lower is straight, and abruptly terminates where it lies against the posterior wall of the tympanic chamber above the position of the opening of communication with the mastoid cells. The *lower process* (stapedial crus, long process) descends vertically in a line nearly parallel to the handle of the malleus. It tapers gradually toward its free end, where it is abruptly deflected inward to terminate in the *lenticular process* (lenticulare Sylvii, os orbiculare) by means of which the incus articulates with the stapes. The lenticular process is distinguished by an annular constriction at its base. In early life the lenticular process is a separate ossicle.

THE STAPES.—The stapes (the stirrup) is lodged between the incus and the oval window. It presents a head, a base, and two crura. The head is a rounded projection placed at the junction of the crura, and presents a concave surface for the lenticular process.

The base is kidney-shaped, and answers to the outline of the oval window. It is nearly straight on one side, and slightly convex on the other. The anterior crus is straight and shorter than the posterior. The space between the crura is marked by a faint groove for the reception of a thin membrane. The lenticular ossicle may become ankylosed to the stapes instead of to the incus. The borders of the base of the stapes are covered with hyaline cartilage.¹

Variations.—The malleus may have a broad, foliated handle and a short neck. A scale-like ossification in the tympanic membrane may be attached to the malleus. The incus frequently exhibits a notch on the lower border of the upper process. The lower process may be inclined toward the inner wall of the tympanum, and even fixed to it. The crura of the stapes may scarcely at all diverge, and the space between them be narrowed. The tendon of the Stapedius muscle may become ossified and ankylosed to the stapes. —The ossicles are always as large in the new-born infant as in the adult, and in some instances are even somewhat larger.

The Ligaments of the Ossicles. The malleus is fixed by three ligaments.

The Anterior Ligament.

The Superior Ligament.

The External Ligament.

The Anterior Ligament extends from the long process to the tympanic bone. This ligament was formerly thought to be a muscle, and received the name of Laxator Tympani.

The Superior Ligament (axial ligament) passes from the head of the malleus to the temporal bone.

The External Ligament extends from the neck of the malleus to the temporal bone. Under the head of the Posterior Ligament, Helmholtz describes a fascicle of the last-named ligament.

The incus is supported by a single ligament which extends from the body of the bone, near the articular facet with the malleus, to the roof of the tympanum.

THE MUSCLES OF THE MIDDLE EAR.

The Muscles of the Middle Ear are—

The Tensor Tympani.

The Stapedius.

THE TENSOR TYMPANI.

The Tensor Tympani arises from the petrous portion of the temporal bone, from the sphenoid bone, and

¹ *Note to the description of the ossicles.* In the above description, the ossicles are assumed to be in relation to the skull rather than to the membrane of the tympanum. A direction toward the face is in "front;" towards the occiput is "behind;" toward the vertex is "above;" toward the base "below;" toward the tympanic membrane is "without;" toward the promontory "within," etc.

from the cartilaginous portion of the Eustachian tube. It is lodged in the semicanalis, becomes tendinous as it passes around the tympanic edge of the partition between the semicanalis and the Eustachian tube (processus cochleariformis), and is inserted by a delicate tendon into the base of the handle of the malleus, upon the inner (tympanic) side of the bone, immediately below the base of the short process.

Function.—To rotate the malleus inward and indirectly to make tense the tympanic membrane.

The length of the tendon from the end of the semicanalis to its insertion on the hammer Weber¹ gives at two and a fourth mm., and its direction as being somewhat forward and downward. Its insertion on the malleus is three and three-fourths mm. from the end of the manubrium, and four and a half mm. below the top of the malleus.

The Tensor Tympani is surrounded throughout its entire course by a fibrous sheath arising from the roof of the tubal cartilage, and from the edge of the fibro-cartilage basilaris, and passing along the entire muscle. The mucous membrane of the chamber does not come in contact with the muscle. Even here its sheath is continuous with that from the osseous portion.

THE STAPEDIUS.

The Stapedius is a small muscle which arises from the cavity within the pyramid. After escaping from this cavity it turns at nearly a right angle, and is inserted upon the anterior side of the neck of the stapes.

According to Rüdinger, the tendon sends a slip to the lenticular process and to the capsule. The same writer describes a small fascicle (*Fixator Baseos Stapedis*) which passes from the upper margin of the oval window to the stapes.

Function.—The Stapedius assists in holding the stapes in position, and draws the head of the bone backward and slightly downward, and relaxes the pressure on the oval window. It thus acts as a check to the inward pressure of the stapes against the labyrinth. The same act of contraction aids in relaxing the tympanic membrane; the muscle thus acts

as an antagonizer to the action of the Tensor Tympani.

Nerve Supply.—The Tensor Tympani secures nerve-fibres from the otic ganglion.

The Stapedius is supplied by the facial nerve.

REMARKS.—The Tensor Tympani muscle undergoes contracture in some forms of chronic deafness, and it has been proposed to divide the tendon as it lies near the neck of the malleus.

The Stapedius muscle is sometimes paralyzed in facial palsy.

THE INNER EAR.

The Inner Ear (the labyrinth) is the essential portion of the organ of hearing. It is situated within the petrous portion of the temporal bone, between the internal auditory meatus and the chamber of the tympanum. It is composed of a membranous labyrinth and a bony labyrinth.

The *membranous labyrinth* is a chamber of irregular form which contains a fluid and particles of carbonate of lime, known as *otoliths*. The chamber receives the terminal filaments of the acoustic nerve.

The *bony labyrinth* is the osseous envelope of the membranous labyrinth.

THE BONY LABYRINTH.

The membranous labyrinth is encased in a bony framework which corresponds to it in form. The bony labyrinth is surrounded by a thin cancellated layer of bone, with the exception of the outer surface which lies upon the inner wall of the tympanic chamber, where it is covered with thin mucous membrane. The cancellated tissue is best developed in the infant, while in the adult it becomes relatively compact. As a result of this disposition, the labyrinth is more difficult to remove from the skull in the adult than in the young subject.

The bony labyrinth (figs. 2, 3, 4, Plate XCVIII.) is composed of—

The Vestibule.

The Semicircular Canals.

The Cochlea.

¹ Monatschr. für Ohrenheilkunde, Oct. 1872.

EXPLANATION OF PLATE XCVIII.

Fig. 1. View of the posterior nares and the relative parts, as seen by reflected light.

Fig. 2. The bony labyrinth in position, as seen from behind.

Fig. 3. The bony labyrinth in position, as seen from above.

Fig. 4. A frontal (transverse vertical) section of the temporal bone with the Eustachian tube in position. Designed more particularly to display the Aquæductus Fallopii (facial canal) and the tympanic chamber.

Fig 1

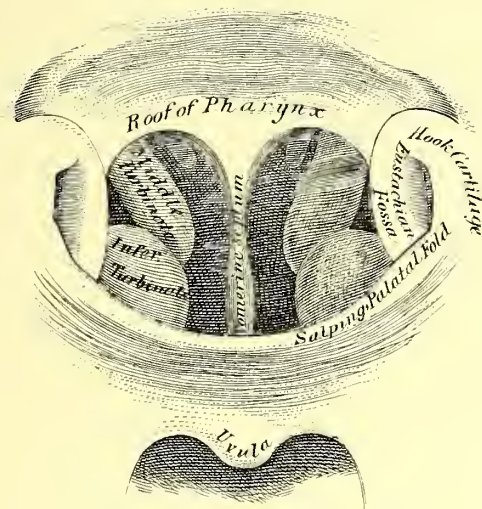


Fig. 2

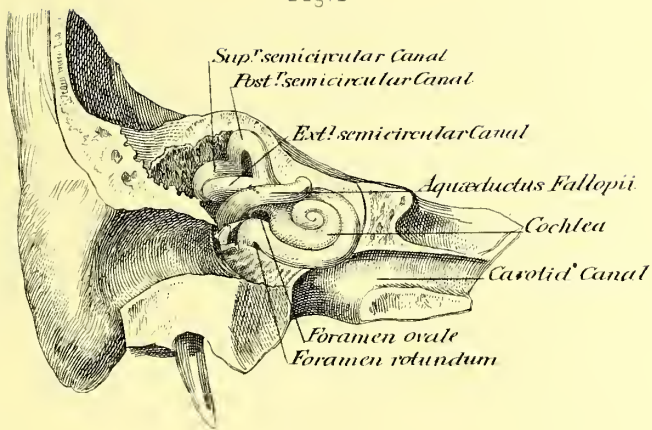


Fig 3

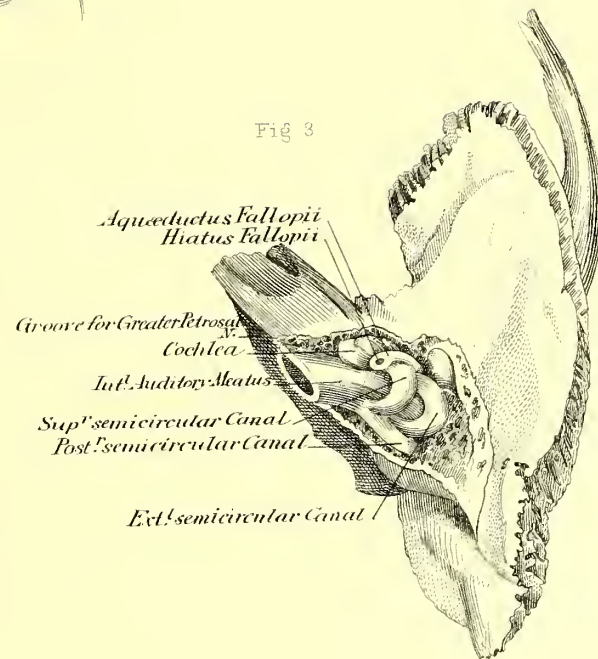
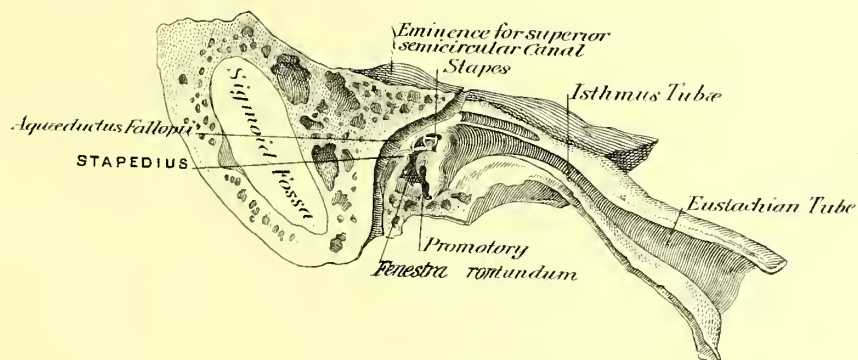


Fig. 4.



THE VESTIBULE.

The Vestibule is a chamber of an irregularly oval shape, and slightly flattened from within outward. It is designed to accommodate the utricle and the sacculus, and communicates with the semicircular canals posteriorly and the cochlea anteriorly. The vestibule measures about one-fifth of an inch in diameter.

The inner wall of the vestibule is marked by a crest (*crista vestibuli*), which serves as the intermediate space between the depression for the utricle (*fovea hemielliptica*), which lies behind the crest, and the depression of the sacculus (*fovea hemispherica*), which lies in front of it.

The vestibule communicates on its outer wall with the middle ear by the *foramen ovale*. It in addition receives the openings of semicircular canals, the *foramina* for the nerves to the membranous labyrinth, and the opening of the *aquæductus vestibuli*.

The *openings of the semicircular canals* embrace the three *ampullæ*, and the orifices of both ends of the horizontal canal, as well as the orifice of the canal resulting from the union of the vertical transverse and vertical longitudinal semicircular canals.

The *openings of nerves*. The nerves for the membranous labyrinth enter the inner wall of the bony labyrinth, through minute openings which are arranged as follows:—

First group (*macula cribrosa superior*) situated at the pyramidal eminence; second group (*macula cribrosa media*) situated below the centre of the *fovea hemielliptica*; third group (*macula cribrosa inferior*) situated near the junction of the inner and the posterior walls with the floor, and within the *ampulla* of the vertical longitudinal semicircular canal.

To these groups may be added a fourth (*macula cribrosa quarta*, Reichert), which lies near the anterior border of the *fovea hemispherica*.

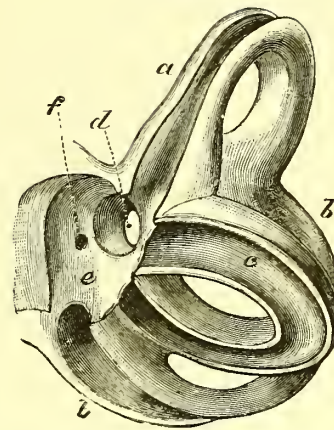
The *opening for the aquæductus vestibuli* lies near the *ampulla* of the external semicircular canal. It conveys lymph from the subarachnoid space to the interior of the vestibule.

The *Aquæductus Vestibuli*. The *aquæductus vestibuli* is a small canal leading backward to the posterior surface of the petrous portion of the temporal bone. In the infant it is much larger than in the adult, and appears as a shallow chink.

THE SEMICIRCULAR CANALS.

The Semicircular Canals are three C-shaped tubes which open into the vestibule. Each tube is slightly compressed laterally, and presents a diameter of one-twentieth of an inch.

Fig. 142.



a, vertical transverse; *b*, horizontal; *c*, vertical longitudinal; *d*, common opening of the two vertical canals; *e*, part of the vestibular cavity; *f*, opening of the aqueduct of the vestibule.

Each tube departs from a plane of a true arch. One of the extremities of each canal is enlarged before it enters the vestibule constituting the so-called *ampulla*.

The canals are named from their respective positions as follows:—

The Vertical transverse.

The Vertical longitudinal.

The Horizontal.¹

(1) The *vertical transverse* canal (superior, frontal) is the largest of the three. It forms a conspicuous swelling upon the anterior aspect of the petrous portion of the temporal bone. Its anterior part forms an *ampulla*; its posterior joins the anterior part of the succeeding canal.

(2) The *vertical longitudinal* canal (posterior, sagittal) extends parallel to the axis of the petrous portion of the temporal bone. It is nearly circular in form, and is the lowest in position of the three. An *ampulla* is developed upon its posterior extremity, the anterior joining the vertical transverse canal.

(3) The *horizontal* canal (external) is the shortest of the three. It extends obliquely from without downward. Its anterior extremity forms an *ampulla*, and opens near the outer wall of the vestibule.

¹ Respecting the synonymy of these names, it may be said that the terms "vertical" and "horizontal" indicate the relations of the canals to the plane of the base of the skull; the terms "transverse" and "longitudinal" to the axis of the petrous portion of the temporal bone; the terms "superior" and "inferior" refer to their position to the plane of the base of the skull; and the terms "anterior" and "posterior" to their position in connection with the longitudinal axis of the skull. If the axis of the auditory nerve were taken as a guide, it would be found that the horizontal semicircular canal would be transverse to this axis, and at the same time external to it.

THE COCHLEA.

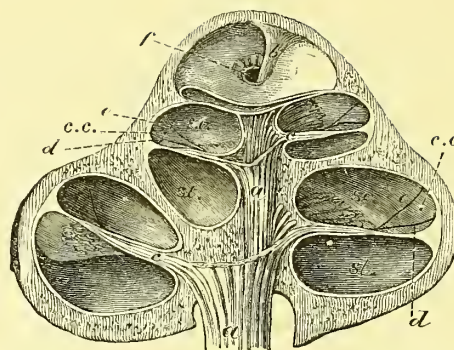
The Cochlea, so called from the resemblance it bears to a snail's shell, is that portion of the bony labyrinth which receives the cochlear canal. The plan of the cochlea is that of a bony tube, turned two and a half times upon itself, and rapidly diminishing in calibre from below upward. The whorls are directed from the left to the right in the right ear, and from the right to the left in the left ear. The basal structures of the cochlea are often included in the term vestibular portion. The apex of the cochlea is called the *cupola*.

The cochlea is directed forward, outward, and downward from the anterior portion of the vestibule, the base of the conic figure presenting toward the internal auditory canal. The cochlea communicates with the vestibule by a large opening (*apertura baseos cochlearis*), and with the chamber of the tympanum by means of the round window. The first whorl constitutes a portion of the inner wall of the chamber of the tympanum, and forms there a conspicuous eminence—the *promontory*. In front of the cupola lies the carotid canal. The cochlea lies in front of the superior petrosal sinus, and near the canal for the Tensor Tympani muscle.

The cochlea is from two to two and a half lines long by three to three and a half in width. The whole tube is about one-and-a-half inch long. Its axis measures fifteen lines in length, while its base is four lines in width.

The cochlear tube circumscribes a small portion of the petrous portion of the temporal bone termed the *modiolus* (*columella cochleæ*), which extends from the base of the cochlea to the level of the second whorl. The modiolus rests upon the bottom of the internal meatus at the spiral tract.—The cochlea also permits a dense lamina of the petrous bone to be received between the first and second whorls, whence it follows the spiral turns of the tube to terminate within the apex. This forms the wall of a small space, which, in consequence of its funnel-like shape, is called the *infundibulum*. The modiolus communicates with the infundibulum by means of a small canal (*canalis centralis modioli*), which extends the entire length of the modiolus. The modiolus and the infundibulum may be compared to two cones touching at their tops: the former is cancellated petrous bone carried within the cochlea at its base; the latter is the termination of a lamina of petrous bone carried into the cochlea from its side.

Fig. 143.



a, axis with its canals; *b*, infundibulum or enlarged upper end of the axis; *c*, septum of the cochlea; *d*, membrane of Corti; *e*, membrane of Reissner; *f*, hiatus or helicotrema; *st*, scala tympani; *sv*, scala vestibuli; *c.c.*, cochlear canal.

The parts above described may be held as related to a hypothetical axis or line which extends from the centre to the base of the cochlea, along the modiolus to the cupola. Such an axis as is produced within and beyond the infundibulum lies to the inner side of the last whorl of the cochlea. The *true* axis of the cochlea is, of course, the axis of the cochlear tube itself, and is a line produced along the course of the tube at a point which answers to the junction of the osseous lamina and the membranous structure transecting the cochlear tube.

When a longitudinal section of the cochlea is made, after maceration of the petrous bone, the modiolus presents the appearance of a tapering shaft, about whose periphery extends a spiral ledge-like line, measuring about one-tenth of an inch in width, called the *lamina ossea spiralis*.

Its free edge extends about half way across the bony cochlear canal, and indicates the division of the canal into two compartments as effected by the membranous lamina in the unmacerated specimen.

The space below the conjoined laminae receives the name of the *scala tympani*, since it terminates at the round window of the tympanum; while that above is known as the *scala vestibuli*, since it opens upon the cavity of the vestibule, where, when the membranous labyrinth is in position, it communicates with the sacculæ.

It will be observed that the *scalæ* do not exist in the macerated specimen, since the bony cochlear canal is not completely divided by the bony spiral lamina.

The plan as above given is modified toward the cupola as follows: The bony lamina terminates in a small hook-like process which is called the *hamulus*. The opening of continuity between the *scalæ* is called the *helicotrema*.

Structure.—The bony lamina consists of a compact tissue at its free edge, as well as upon the upper and lower surfaces; but within it is porous. It is continuous with the similar structure of the modiolus, and is distinguished from it by numbers of minute anastomosing canals, which transmit the cochlear nerves and bloodvessels to the membranous cochlea. Winding spirally around the modiolus, beneath the lamina spiralis, is a small canal called the canalis spiralis modioli (spiral canal of Rosenthal).

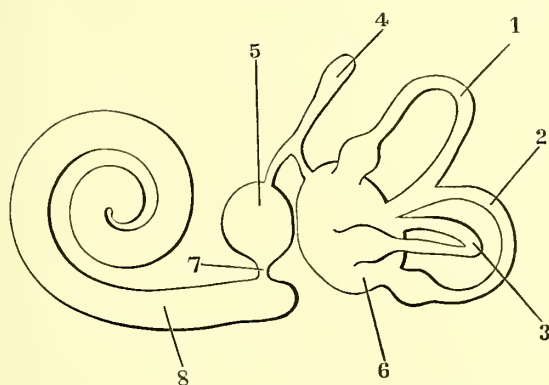
The Aquæductus Cochleæ. This is a small canal leading from the cochlea at the tympanic scala to the base of the skull. It is of a triangular shape, and is situated upon the ridge which lies between the carotid canal and the jugular fossa. It conveys the perilymph from the cochlear scale to the subarachnoid space.

THE MEMBRANOUS LABYRINTH.

The Membranous Labyrinth is the true organ of hearing, and to it the terminal filaments of the auditory nerve are distributed. It lies within the bony labyrinth, to which it corresponds quite closely in form, though it does not completely fill the various cavities of this structure, being separated therefrom for the most part by a serous fluid called the *perilymph*.

The membranous and bony labyrinths are in contact at the points where the auditory nerve enters the former, and along the convex border of the cochlea.

Fig. 144.



Diagrammatic outline of the membranous labyrinth.

1. Vertical transverse s. c. canal; 2. Vertical longitudinal s. c. canal; 3. Horizontal s. c. canal; 4. Recessus labyrinthi; 5. Saccule; 6. Utricle; 7. Canalis reuniens; 8. Canal of the cochlea.

The membranous labyrinth¹ consists of six chief parts—

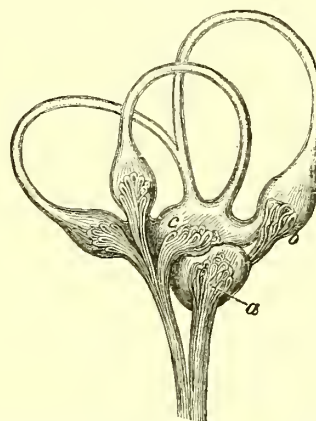
- The Utricle.
- The Saccule.

¹ The term membranous labyrinth is used by some German writers (see Rudinger and Waldeyer, Stricker's Handbuch) as distinct from the cochlea, which is separately treated.

- The Semicircular Canals.
- The Canal of the Cochlea.
- The Canalis Reuniens.
- Recessus Labyrinthi.

The membranous labyrinth is composed of a central portion which answers in position to the vestibule, and is divided into a posterior chamber—the *utricle*—lodged in the fovea hemielliptica and the remaining portion of the vestibule not occupied by the saccule,¹ and an anterior chamber—the *saccule*—which is lodged in the fovea hemispherica. The utricle is a part of the system of the semicircular canals, and the saccule is a part of the system of the cochlea. The utricle, in a marked degree, and the saccule, in a slight degree, are slightly compressed from before backward. Both the utricle and the saccule contain a circumscribed collection of crystals of carbonate of lime (otoliths, otoconia) which is fixed to the inner wall. Each semicircular canal expands into a flask-shaped chamber toward the *ampulla*, which corresponds in form and position to the ampulla already described in the account of the bony labyrinth. The utricle, saccule, and the ampullæ are united to the periosteum of the bony labyrinth at points which answer to the entrance of nerve-filaments.

Fig. 145.



The membranous labyrinth and the distribution of the auditory nerve (diagrammatic). *a*, branch to saccule; *b*, branch to ampulla of the vertical longitudinal semicircular canal; *c*, branch to utricle.

Each of the semicircular canals exhibits on transverse section an oval lumen, and is occupied by three layers—an outer, a middle, and an inner.

The *outer layer* (membranous layer) is fibrous, and, as already stated, is fixed to the periosteum at certain points of the bony labyrinth.

¹ The utricle is represented by many writers as confined to the fovea hemielliptica. The author has followed Henle (see fig. 144) in the above description.

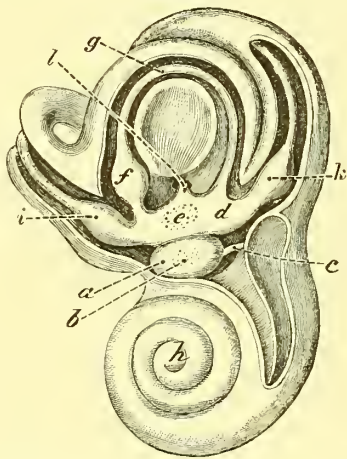
The *middle layer* (lamina propria) is structureless, and forms the bulk of the wall of the canal. It is thinnest opposite the points of fixation to the periosteum.

The *inner layer* (epithelial layer) is tessellated, with an occasional papillar aggregation. Hence the section of the layer presents a wavy appearance.

In the ampullæ, the posterior or the fixed wall sends inward a partition-like projection (crista acustica), which answers to the place of termination of the nerve-filaments.

The structure of the utricle and of the sacculæ in no wise differs from that of the semicircular canals and of the ampullæ.

Fig. 146.



A diagrammatic plan of the labyrinth. *a*, saccule; *b*, entrance of nerve-filaments to saccule; *c*, aqueductus vestibuli; *d*, utricle; *e*, entrance of nerve-filaments to utricle; *f*, ampulla of horizontal semicircular canal; *h*, cupola; *i*, ampulla of the vertical transverse semicircular canal; *k*, ampulla of the vertical longitudinal semicircular canal; *l*, opening of the canal of union of the vertical longitudinal and vertical transverse semicircular canals.

CANALIS REUNIENS.

The Canalis Reuniens is a small passage connecting the saccule with the cochlear canal.

RECESSUS LABYRINTHI.

The Recessus Labyrinthi is a delicate tube which lies within the aqueductus vestibuli, and which connects with the saccule and with the utricle. It is lined with epithelium and ends blindly (sæcus endolymphaticus) in the dura mater near the orifice of the aqueductus vestibuli.

The Endolymph. The endolymph is the lymph-fluid which occupies the membranous labyrinth. It fills all portions of the main central cavity, the semicircular canals, the cochlear canal and the recessus labyrinthi.

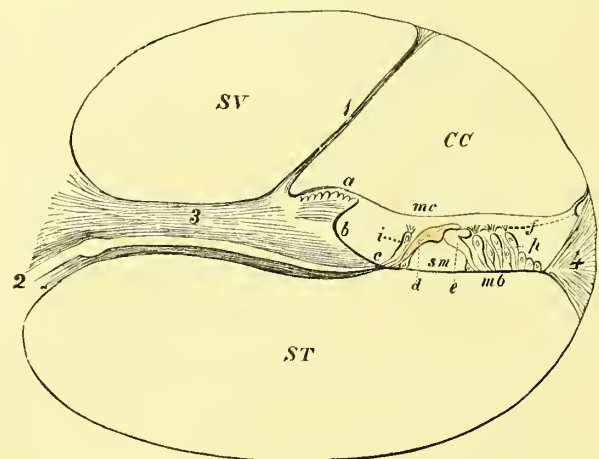
The Perilymph. The perilymph is a lymph-fluid which occupies the space between the membranous labyrinth and the walls of the bony labyrinth and the cochlear scalæ, namely, the entire cochlea with the exception of the cochlear canal. It communicates by the aqueductus cochleæ with the subarachnoid lymph-space.

THE COCHLEAR CANAL.

The anterior portion of the sacculæ contracts abruptly to form a small canal which has received the name of the *canalis reuniens*. It extends downward and forward, and communicates with the cochlear canal.

The Cochlear Canal (scala media, membranous cochlea, ductus cochlearis) begins by a broad opening at the lower and anterior portion of the vestibule. It at once enters the cochlea, where it lies in the space between the outer wall of the canal and the outer free edge of the lamina ossea spiralis, and aids in defining the scala, but lies on a plane above that of the lamina. As seen in a vertical section of the cochlea, the cochlear canal presents a triangular appearance; the base of the figure corresponds to the outer wall of the cochlea, the apex to the edge of the lamina ossea spiralis, the lower side to a membrane (basilar membrane) which extends horizontally outward between the lamina ossea spiralis and the outer wall of the cochlea, and the upper side to a second membrane (membrane of Reissner, membrana vestibularis) which extends obliquely upward and outward.

Fig. 147.



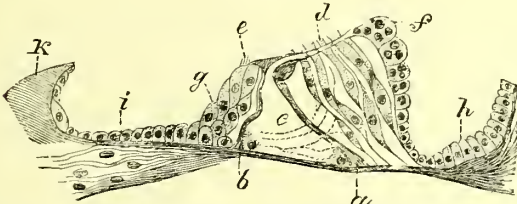
Section through one of the coils of the cochlea, showing the organ of Corti (diagrammatic); *SV*, scala vestibuli; *ST*, scala tympani; *CC*, cochlear canal; *b*, spiral groove; *d*, one of the inner rods of Corti; *e*, one of the external rods of Corti; *f*, lamina reticularis; *i*, one of the inner hair-cells; *p*, external hair-cells; *mc*, membrana tectoria; *sm*, tunnel of Corti; *mb*, membrana basilaris; *1*, membrane of Reissner; *2*, cochlear nerve; *3*, lamina ossea spiralis; *4*, position of ligamentum spirale coarsely represented.

The lamina spiralis modioli projects in the cupola over the hamulus, and thus embraces an opening, the helicotrema Brescheti, through which the *scala tympani* and *scala vestibuli* communicate.

Structure.—The structure of the cochlear canal is much more complex than is that of the other portions of the membranous labyrinth. Continuous with the lamina ossea spiralis is a membranous structure which extends across the cochlear tube, and which serves to separate the vestibular from the tympanic scala. At the inner third of the bony lamina the membrane of Reissner is attached.

The membrane is fixed to the terminal third of the vestibular surface of the bony lamina, and terminates in a thickened extremity which is called the *limbus spiralis*. Beneath the limbus and between it and the apex of the bony lamina is the *inner spiral groove*. The *basement membrane* extends from the free edge of the bony lamina horizontally across the cochlea to the outer wall of the canal, where it aids in defining the *outer spiral groove*. Resting upon the basement membrane is a layer of epithelial cells.

Fig. 148.

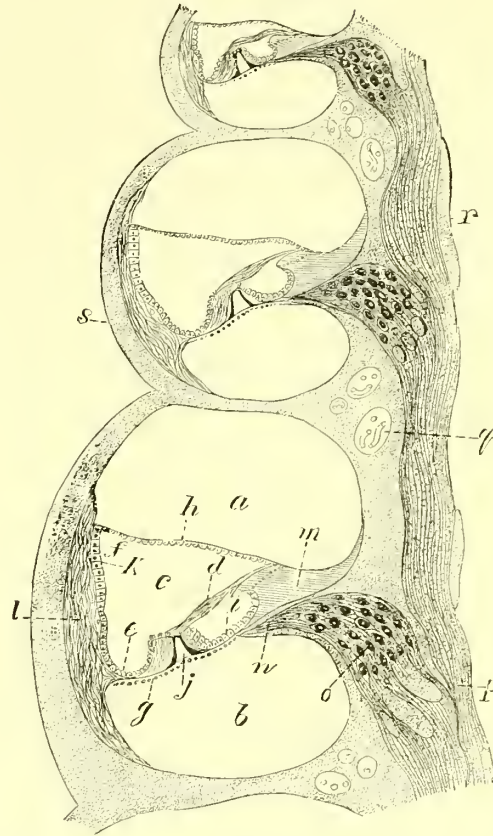


Organ of Corti of the cochlea of a Guinea-pig. *a*, outer rod or pillar of Corti; *b*, inner rod or pillar of Corti; *c*, tunnel of Corti's arch; *d*, outer hair-cells; *e*, inner hair-cell; *f*, outer supporting cells containing fat globules; *g*, inner supporting cells; *h*, cells; *i*, epithelial cells lining the sulcus spiralis internus; *k*, part of crista spiralis.

The Organ of Corti. Lying upon the basement membrane, and lying a little nearer the inner than the outer spiral groove, is a delicate complex structure which has received the name of the organ of Corti. Seen in transverse section the organ of Corti resembles an arch whose sides (inner and outer) are termed the *rods of Corti*, the parts uniting the rods at their summits are termed the *roof-cells* (phalangeal cells), which compose the *reticular lamina*, and the archway defined by the rods is termed the *tunnel of Corti*. To the inner side of the inner rods lies a row of cells (cells of Deiters) surmounted by minute hairs. These cells are known as the *inner hair-cells*. To the outer side of the outer rods lie three or four rows of similar cells, which are called the *outer hair-cells*. The reticular lamina is, as the name expresses, a membrane of a delicate open network of fibres through which the hair-cells project free above the entire Cortian organ.

The entire structure is covered with a delicate and somewhat elastic membrane (the *membrana tectoria*), which extends from the limbus spiralis across and

Fig. 149.



Vertical section through the cochlea of a Guinea-pig's ear, seen in the long axis of the modiolum. *a*, scala vestibuli; *b*, scala tympani; *c*, cochlear canal; *d*, membrana tectoria; *e*, cells; *f*, upper outer angle of the scala media; *g*, region of the outer hair-cells on the membrana basilaris; *h*, membrane of Reissner; *i*, epithelium lining the sulcus spiralis (internus); *j*, tunnel of Corti's arch; *k*, stria vascularis; *l*, ligamentum spirale; *m*, crista spiralis; *n*, nerve-fibres; *o*, ganglion spirale; *p*, nerve-fibres in the modiolum; *q*, channels in bone containing bloodvessels; *r*, masses of bone in the modiolum; *s*, bony capsule.

over the organ of Corti to join the epithelial cells of the basement membrane some distance beyond the outer hair-cells.

Thus, to recapitulate, there exist in the organ of Corti an inner and outer series of *rods of Corti*; an inner and outer series of *hair-cells*; a series of roof-cells which constitute the *reticular lamina* placed upon the conjoined apices of the rods, and a second covering membrane to the whole organ the *tectorial membrane*.

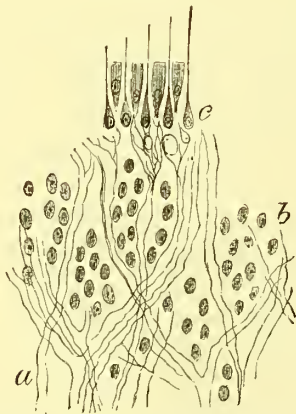
For a more minute description of this remarkable structure, the student is referred to the special memoirs of Kölliker and Waldeyer, or to a careful *résumé* of the later views in Quain's Anatomy, ninth edition.

The Nerves of the Inner Ear.—The auditory nerve, after leaving the internal auditory meatus, divides into two branches, one for the cochlea and the vertical longitudinal canal, and the other for the saccule, the utricle, and the vertical transverse and horizontal canals. The latter in turn divides into two branches: A. One of these again divides into three, which are designed (1) to supply the ampulla of the vertical transverse semicircular canal; (2) to supply the ampulla of the horizontal semicircular canal; and (3) to supply the otoliths of the utricle.—B. The other branch supplies the otoliths of the saccule, and sends the remaining bundle of filaments by a special route, viz., through a small bony passage behind the position of the foramina for the nerve of the saccule to the ampulla of the vertical longitudinal canal.

The nerve for the cochlea passes along the spiral tract to enter the modiolus. It soon divides into a great number of branches, which escape through the porous intervals between the vestibular and tympanic plates of the lamina ossea spiralis, to be received within the epithelial structure of the organ of Corti. Their ultimate destination, however, is the basement membrane beneath the organ of Corti.

The filaments for the terminal portion of the cochlear duct are not received from the side as above described, but by a number of special fibres transmitted vertically the entire length of the cochlea, through the canalis centralis modioli.

Fig. 150.



From a transverse section through the macula acustica of the utricle of the labyrinth of a Guinea-pig. *a*, medullated nerve-fibres, forming plexuses; *b*, nuclei of the membrane; *c*, sensory epithelium (diagrammatic); spindle-shaped sensory-cells possess long auditory hairs projecting between the conical epithelium cells beyond the free surface.

Just prior to their exit from the modiolus, the cochlear nerves are enriched with nerve-cells. This tract is situated within the canalis spiralis modioli already noticed.

The above account is abridged from Breschet. According to G. Retzius, the vestibular branch supplies the utricle and the ampullæ of the vertical longitudinal and the horizontal semicircular canals, while the cochlear branch supplies the cochlear canal, and the ampullæ of the vertical transverse semicircular canal.

Bloodvessels of the Inner Ear.—The arteries of the membranous labyrinth are derived as follows: For the semicircular canals, the utricle and saccule, the internal auditory artery or the superior cerebellar artery. Communicating branches are derived from the arterial supply of the tympanic chamber. They may also receive branches from the stylo-mastoid, from the posterior auricular, or from occasional branches of the occipital artery.

For the cochlea a number of twigs enter the modiolus and form a network occupying the interstices in the lamina ossea spiralis and the outer wall of the cochlear canal.

REMARKS.—The auditory nerve may undergo atrophy either in whole or in part. This condition is probably caused by lymph-stasis, or atheromatous degeneration of the auditory artery, though it may be limited to a portion of the fibres of distribution. The parts of the cochlear nerve which supply the basal convolution of the cochlear canal may be separately involved.¹ After obliteration of the semicircular canal in animals, the cells of the cerebellar cortex undergo degeneration.² Peripheral disease of the nerve is thus seen to be followed by the same class of changes in the central nervous system previously known to exist in the case of the optic nerve. After destruction of the internal ear, the auditory nerve may undergo progressive fatty degeneration.³

Concretions of phosphate of lime may form in the neurilemma.⁴ Moos⁵ has found them in chronic deafness associated with subjective noises. For additional remarks see p. 617.

THE INTERNAL AUDITORY MEATUS.

The Internal Auditory Meatus extends from the posterior surface of the petrous portion of the temporal bone, toward the vestibule, to the base of the cochlea. Its direction is directly outward. It is between five and six lines long, and two lines wide.

¹ S. Moos and Steinbrügge, *Archives of Otology*, 1881, x. 10.

² Stephani and Weiss, for reference and comment see C. Spanier, *Pflüger's Archiv für die gesammte Physiologie*, 1879, xxi. Nos. 10 and 12.

³ O. Weber, Pitha, and Billroth's *Chirurgie*.

⁴ Böttcher, *Virchow's Archiv*, xii.

⁵ See abstract in *Archives of Otology*, 1879, viii. 96.

The bottom of the meatus is divided into two parts by a crest (*crista falciformis*). Above the crest are situated two small fossæ. The anterior of these is designed for the entrance of the facial nerve into the *aquæductus Fallopii*. The other, the smaller of the two, receives the branch of the vestibular nerve for the utricle, the ampullæ of the vertical transverse and the horizontal semicircular canals. Below the crest are tracts for the entrance of the branches of the cochlear nerve to the modiolus, while at the posterior part of the base of the meatus are two or three minute rounded openings for the branch destined for the ampulla of the vertical longitudinal semicircular canal, and for the nerve to the sacculæ.

Variations of the Labyrinth.—The posterior end of the ampulla of the horizontal canal has been found dilated by Gerlach.¹ The semicircular canals may be absent either on one or both sides of the body. Defective semicircular canals imply defect of the cochlear whorls, while an abnormally formed cochlea may exist with normal semicircular canals.

The diameters of the labyrinth may be narrowed by hyperostosis.

The foramen rotundum may rarely open upon the vestibule instead of the cochlea.

Hyrŕl found the *aquæductus vestibuli* absent, and in a second instance two passages present. Both the *aquæductus vestibuli* and the *aquæductus cochleæ* may be abnormally widened. Ibsen found the *aquæductus vestibuli* unusually large in deaf mutes.

REMARKS.—The medical applications of a knowledge of the anatomy of the labyrinth and internal auditory meatus include the following:—

(a) The localization of diseased action in the bony labyrinth.

(b) The extension of disease to the labyrinth by continuity from the chamber of the tympanum.

(c) The relations between the degree of pressure existing in the subarachnoid lymph-space, and that in the labyrinth.

(d) Localization of disease in the internal auditory meatus.

(a) The early and complete ossification, the nourishment by means of non-anastomosing vessels, and the compact structure of the bone, are factors entering into the question of necrosis of the labyrinth. Notwithstanding such predisposing conditions idiopathic necrosis is of less frequent occurrence than caries.

The labyrinth may be involved in caries and in necrosis of the petrous portion of the temporal bone. Since such a process is commonly the sequel of

chronic suppurative disease of the middle ear, those portions exposed upon the inner wall of the chamber of the tympanum most commonly suffer. Sequestra containing the basal portion of the bony cochlea or of the entire cochlea have been removed from the living subject. In less frequent instances portions of the semicircular canals and vestibule have been removed. The effect of chronic otitis media is to induce hyperostosis of the petrous portion and the mastoid portion of the temporal bone. Foci of carious degeneration are scattered throughout the mass, being more especially located upon the bony labyrinth. Hyperostosis may narrow or occlude the round window, and excite the formation of nodosities upon the inner wall of the labyrinth.

The horizontal semicircular canal and the vertical transverse semicircular canal are relatively near the facial canal, and may thus be involved in necrosis involving these portions of the labyrinth.

A. Lucæ¹ reports the removal from the external auditory canal of a necrosed fragment which was identified with the upper two-thirds of the cochlea. The patient had had vertigo and bloody purulent discharge from the ear, which symptoms disappeared after the removal of the fragment.

Embolism of the auditory artery may cause the death of the entire labyrinth.

(b) In addition to disease of the tympanic chamber extending to the labyrinth through the general bony investment of the petrous bone, the round and oval windows afford means of direct continuity between the two portions of the ear. The oval window, closed as it is by the stapes in normal condition, would ordinarily separate the middle from the inner ear, but it should not be forgotten that the stapes may itself be absent. The most frequent means of communication is by the round window, the single factor of interference being the occluding membrane.

(c) Since the inner ear, by means of its lymph communicates with the subarachnoid space (through the internal auditory meatus, and at the base of the latter passage with the perilymph), the pressure in the labyrinth is in a measure under the control of the fluid in that space. In some forms of deafness, attributed to the increase of this pressure, it may exist within the cranium independently of interference with the auditory nerve.

In cerebro-spinal meningitis, the inflammatory state

¹ Physico-Med. Soc. of Erlangen, Nov. 10, 1879.

¹ Archiv für Ohrenheilkunde, 1875, iv. 4.

of the subarachnoidal membrane may be transmitted by continuity to the labyrinth. A. Lucæ¹ dissected the ear of a subject dying from the above disease, and found the labyrinth in a state of suppurative inflammation, but with no involvement of the nerve-trunks.—J. W. Ogle² attributes the implication of the base of the brain, in some forms of suppuration of the inner ear, to a morbid element extending from the ear to the arachnoid membrane by the prolongation of that structure along the internal auditory meatus.

(d) Tumors have been detected protruding within the internal meatus. Clots may form within the passage, and syphilitic growths have been here located.³

CONCLUDING REMARKS ON THE MIDDLE EAR.⁴

THE TYMPANIC CHAMBER.—Meckel⁵ describes a space between the triangular eminence, the promontory, and the oval window, which he named the sinus tympani. H. Steinbrügge⁶ describes the sinus as follows: An excavation on wall of labyrinth beneath the canal for the facial nerve to a point near the ampullar end of the vertical transverse semicircular canal, and its deepest portion reaches to a point below the floor of the tympanum.

Flesh⁷ believes that the opening occasionally seen in the roof of the tympanic chamber is the result of maceration, and that the absence of bony covering in the living substance is an exceedingly rare occurrence.

The mastoid process contains but a single open space (antrum petrosum) in new-born children.⁸

Politzer enumerates the base of the styloid process among the component parts of the floor of the tympanic chamber.

The mastoid process, when examined in the dried bone of the adult, gives erroneous conceptions of the nature of the cells. Many of them are pneumatic, but others, according to E. Zuckerkandt,⁹ are filled with fat. The proportion of air-cells and fat-cells is variable. In 39.8 per cent. of cases the cells are wholly pneumatic; in 20 per cent. wholly fat-containing; and in 43.2 per cent. both kinds were present

in nearly equal proportions. The extension of the inflammation of the lining membrane to the mastoid cells is a complication which is thus seen to be dependent upon variations, and upon anatomical grounds alone is seen to be a lesion unlikely to occur in at least 20 per cent. of cases, from the fact that in this proportion no air-cells exist.

Berthold¹ concludes that the mucous membrane of the middle ear receives its trophic fibres from the fifth nerve. Evulsion of this nerve or its section was followed by "vascularization" and "purulent exudation." Similar treatment of the sympathetic and the ninth nerves had no effect.

The Ossicles.—The ossicles tell the story of their origin in the manner in which they vary, in the portions of the bones attacked by disease, and in the ratio of the attack itself among the several bones of the series. Both of the above statements again correlate with the facts of development, and in a measure with the condition of the bones in animals lower than man.

Additional Variations.—In addition to the variations already described on page 609, it may here be stated that as the stapes shows the widest range and greatest frequency of variation of any of the ossicles, so it is the most commonly affected by disease. It is also the bone which exhibits to the greatest extent the effects of advanced age. In this state the base of the stapes is subject to hyperostosis and as a consequence to impaired motility. Ankylosis between the stapes and the borders of the oval window may in like manner occur.

The fact that the stapes is an ossicle somewhat isolated in its development from the incus and the malleus, and that it has little or no genealogical significance, may account for its inconstancy in form, and its inability, relatively, as compared with the other ossicles, to resist the encroachments of diseased action.—While the stapes is the most variable the malleus is the least so. The short process and the handle may be absent in congenital defects of the tympanic membrane.

In a case of deaf-mutism reported by S. Moos,² the stapes was found in position, a part of the base being absent, while the incus and the malleus were absent.

The slender and short processes of the malleus may be united by a trace of a thin lamina which is homologous with the broader lamina constant in some carnivorous mammals. All the ossicles may

¹ Archiv f. Ohrenheilk., v.

² Trans. Path. Soc. Lond., 1859, x. 34.

³ Knapp, Trans. Med. Soc. of New York, 1872.

⁴ These remarks are to be considered as an addendum to the account of the middle ear, p. 604.

⁵ Handbuch der menschl. Anat., 1820.

⁶ Archives of Otolaryngology, 1879, viii. 53.

⁷ Archiv für Ohrenheilkunde, xviii. 65.

⁸ Wildermuth, Zeitsch. für Anat. u. Entwicklungsgesch. II.

⁹ Monatsch. für Ohrenheilkunde, 1879. No. 1.

¹ Trans. Fifty-third Congress of German Scientists and Physicians, 1880.

² Arch. of Ophthal. and Otol. II., 1871, 39.

coalesce in a single rod which represents the columella of the lowest mammals, birds, and the cold-blooded terrestrial quadrupeds generally. The stapes and incus may be fused into a single bone. A supernumerary bone may lie between the malleus and the incus. The upper process of the incus may exceed the lower in size.

Diseased Action.—It has been seen above that the stapes exhibits a greater number of kinds of diseased action than either the malleus or the incus. Among additional facts may be mentioned that, while in the stapes the head and crura are most prone to caries, in the malleus it is the head of the bone which is most commonly attacked.

The handle of the malleus, owing to the fact that this portion of the bone receives its blood in part from an artery passing into the bone from the vessels of the tympanum, rarely becomes carious.

The incus, as it lies near the inner wall of the tympanum, is subject to exostosis. The space between the lower and upper processes may be filled with new formations of bone-tissue.

The ossicles may be entirely destroyed by caries independently of the rest of the ear.

The Articulations of the Ossicles.—The intrinsic or inter-serial articulations are as follows: the malleo-incudal, the incudo-stapedial, and the stapedo-vestibular. These are all of the nature of symphysis, according to Brunner.¹ The extrinsic articulations are confined to the malleo-tympanic and the incudo-tympanic junctures, and are less of the nature of articulations than of accessory union by ligamentous attachment.

The Muscles of the Middle Ear and of the Eustachian Tube.—The Tensor Tympani muscle has been found by Von Trœltzsch to be continuous with the Tensor Palati either by a tendinous band or by a muscular fascicle. This connection explains the concurrence of retraction of the tympanic membrane with the action of the Tensor Palati as occurred in a case of C. H. Burnett.²—Paralysis and paresis of the muscles of the orifice of the Eustachian tube and of the Tensor Tympani have been found by Weber-Liel and E. Woakes to be associated. The former writer has found in paralysis of the Tensor Palati muscle antagonistic contraction of the Tensor Tympani to co-exist.

The concurrence of weakened and inefficient action of the two muscles may be anticipated, not only from the fact of partial fusion of the two mus-

cles above mentioned, but from the fact that both receive nerve-fibres from the same source, namely, the otic ganglion. It would be a mistake to assume, however, that paresis of the tubal muscles of necessity is associated with paresis of the Tensor Tympani. The author has met with numerous examples of entire retention of the functions of the middle ear with paresis of the Tensor Palati and Levator Palati muscles.

The point of insertion of the Tensor Tympani has been found by V. Urbantschitsch subject to considerable variation. As the result of many dissections he found it twice only attached to the inner surface of the manubrium. In nineteen times it was attached to the outer, thirty times to both the outer and inner surfaces.

The Eustachian Tube.—The tube may be either narrower or wider than is normal. It may be unduly angulated at the osseous portion. The position of the pharyngeal orifice of the tube is subject to some slight variation. According to S. Moos,¹ the orifice becomes narrowed in chronic inflammation of the tube.

The Stapedius Muscle.—The pyramid and the Stapedius muscle can be occasionally seen in cases of perforation of the posterior quadrant of the tympanic membrane, and V. Urbantschitsch² has successfully divided the tendon of the muscle thus exposed for the relief of deafness and noises in the ear.

THE NOSE.

The Nose is the organ of olfaction. It is lodged in a chamber which is in the main of respiratory significance, and is defined by the bones of the face.

For convenience of description the nose is divided into—

- The External Nose.
- The Nasal Chambers.

THE EXTERNAL NOSE.

The External Nose (fig. 2, Plate XCIII.) holds the same relation to the nasal chambers as the auricle holds to the ear or the eyelids to the eye.

It is composed of—

- The Nasal Bones.
- The Nasal Cartilages.
- The Nasal Muscles.
- The Integument.

¹ Archives of Ophthal. and Otol. III., 1873, 145.

² Phil. Med. Times, 1875.

¹ Archives of Ophthal. and Otol., vi., 1877, 547.

² Wiener Med. Presse, 21, 1877.

The Nasal Bones are described on p. 138; and the Nasal Muscles on p. 249. The septal cartilage is not described.

The Nasal Cartilages are—

The Lateral Cartilages.

The Septal Cartilage.

The Sesamoid Cartilages.

The Lateral Cartilages are composed of the upper lateral and the lower lateral.

Each *upper lateral cartilage* is triangular in form, and is continuous with the cartilage of the septum. The anterior margin of each cartilage is thicker than the posterior, and is attached to the ascending process of the superior maxilla and to the nasal bone of the corresponding side of the face. The outer (lateral) border is visible within the vestibule, where it is covered with mucous membrane.

The *lower lateral cartilages* enter into the construction of the tip of the nose. They are distinct from the septum, and each cartilage is bent abruptly upon itself, the outer aspect of the angle being directed anteriorly. A depression often exists in the interval between the angles of the right and left lower lateral cartilages. One of the lines of bending—the internal—inclines toward the septal cartilage; while the other—the external—inclines toward the wing of the nose, and aids in defining the shape of the nostril. The inner line is much the smaller, and lies beneath the *septal cartilage* in contact with the similar process of the cartilage of the opposite side. It terminates abruptly at a point in advance of the anterior nasal spine of the superior maxilla. The outer line is broad and flat, and is subject to much variation in form.

THE SESAMOID CARTILAGES.

The sesamoid cartilages (accessory cartilages, epacral cartilages) are three or four in number. They are flat, subrounded nodules which are placed in the tough fibrous membrane of the wing of the nose. A conspicuous pair (vomarine cartilages) is placed one on either side of the nasal septum. In addition to the fibrous tissue and the sesamoid cartilages, the wings of the nose contain a quantity of fat and sebaceous glands. Hair follicles are also sparsely developed.

THE INTEGUMENT.

The integument is thin on the bridge and at the sides of the nose, where it is easily moved by the fingers. Toward the region of the cartilages the skin can be moved separately from the cartilages

with difficulty, if at all. Two regions can be thus defined. The point at which the fingers are unable to raise a fold of skin from the external nose limits the region of the tip of the nose.

REMARKS.—The cartilages constitute the main support of the lower part of the nose. Aquiline noses are apt to be associated with thin cartilages and with narrow nostrils; while small flat noses usually possess large rounded nostrils. The former variety is usually found in long narrow heads, and the latter in short high heads. The roof of the mouth is again usually more highly arched, and the alveolar ridges less curved in the former than in the latter. As a consequence of these facts, the external nose is of significance in correlation with the shape of the head and especially of the facial bones. In some individuals the extremes of these tendencies are so pronounced as to lead to the localization of diseased action in the nasal chambers. With the aquiline nose, nasal obstruction is often associated; and with the small flat nose, lack of proper protection of the nasal chambers.

THE NASAL CHAMBERS.

The Nasal Chambers (fig. 2, Plate XXIV.; fig. 152), as far as they are defined by the skeleton, have been described on pp. 152, 153. When the external nose remains in position, and the mucous membrane is intact, each nasal chamber may be divided into the nasal chamber proper and the vestibule.

The Nasal Chambers proper.

The Vestibule.

The Nasal Chambers proper are defined by the turbinated bones laterally, and the maxillæ and the palatal bones inferiorly.

The Vestibule is defined by the nasal bones anteriorly, and by the ascending processes of the superior maxillæ, and the nasal cartilages externally. Internally it is defined in part by the incisorial portion of the superior maxilla.

Each vestibule has the shape of a flask, flattened on one side, with the neck prolonged, compressed, and directed upward. The inner wall is formed below by the inner arm of the lower lateral cartilage, by a groove answering to the membranous septum, and above by the septal cartilage. The outer wall is formed by the outer arm of the lower lateral cartilage, by a depression behind it defined by the fibro-adipose tissue of the wing. The roof is continuous with that of the nasal chamber. The floor is depressed a little below the level of that of the nasal chamber, so that such an instrument as an Eustachian catheter is best introduced by first

elevating the tip of the nose. The superior orifice of the vestibule is a mere chink, and, in consequence, affords little or no aid in the introduction of instruments into the nasal chamber for the removal of morbid growths. The inferior orifice (the nostril) is an ellipse, whose internal border is nearly straight, and whose external border describes a curve with the posterior extremity, as a rule, more rounded than the anterior. Both outer and inner aspects of the vestibule near the nostril, as well as the pocket at the tip, are furnished with stiff hairs in patches. Looking at the nostril by the aid of a strong light, when the head is thrown back, one sees the following points: 1st, a darkish chink, far within which is the posterior orifice of the vestibule; 2d, on the outer side, the ridge formed by the inferior border of the upper lateral cartilage; 3d, on the same side, a ridge formed by the outer limb of the lower lateral cartilage.

At a point answering to the posterior border of the outer arm of the lower lateral cartilage, a voluntary contraction is made possible by the tilting of this border inward toward the septum, at the same time that the wing of the nose is depressed and abducted. Most persons can also occlude *one* nostril at a time by adducting the ala. This action, incomplete in man, is pronounced in many quadrupeds, in which we may presume occlusion of the vestibules may be announced by the powerful adduction of the cartilages of the wing directly to the septal cartilage.

The nasal chambers are lined with mucous membrane which is thin, and resembles periosteum over the nasal bones, the ascending processes of the superior maxilla, the nasal cartilages, the floor of the nose, and the sinuses; but is erectile over the inferior turbinated bones, and the lower free border of the middle turbinated bones.

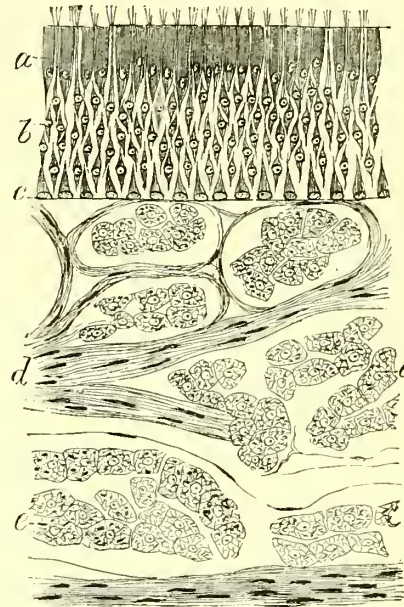
The nasal chambers may be considered as the repository of the *olfactory organs*, and as parts of the *respiratory apparatus*.

THE OLFACTORY ORGANS. These are two in number; one for the left and one for the right nasal chamber. The left olfactory organ is composed of a special membrane which covers the median aspect of the left lateral mass of the ethmoid bone, and the upper half of the left side of the septum. The organ also includes the roof of the left nasal chamber. The right olfactory organ is composed of a similar membrane, which covers the median aspect of the right lateral mass of the ethmoid bone, the upper half of the right side of the septum, and the roof of the right nasal chamber.

The *olfactory membrane* is a modification of the

mucous membrane of the interior of the nose. It is thick and soft as compared with the mucous membrane covering the nasal bones and the sinuses, but is not erectile. It is of a yellowish-brown color, and is rich in cellular elements, but in man at least not ciliated.

Fig. 151.



From a vertical section through the olfactory mucous membrane of the Guinea-pig. *a*, the epithelial cells; *b*, the sensory or olfactory cells; *c*, the deep epithelial cells; *d*, the bundles of olfactory nerve-fibres; *e*, the alveoli of Bowman's glands.

The accessory chambers to the nose include the frontal sinus and the maxillary sinuses. The nasal chamber also receives the lachrymo-nasal duct.

THE RESPIRATORY APPARATUS. The respiratory portion of the nose may be roughly described as that portion which accommodates the air in its passage through the nose. The air in inspiration enters the nostril and passes into the pharynx at the posterior nares. In automatic breathing, the air passes scarcely at all in inspiration above the plane of the lower border of the middle turbinated bone, but an entrance into the region of olfaction, either between the anterior end of the middle turbinated bone and the nasal bone, or between the middle turbinated bone and the septum, may be held as possible. In expiration, the air entering each chamber at the posterior nares is carried along the floor of the nose, the middle meatus, and the space between the inferior turbinated bone and the septum. In many subjects the air also passes between the posterior end of the middle turbinated bone and the septum. The passage of the air in the nose differs in inspiration and expiration. In inspiration it possesses a

slight tendency to pass upward to the olfactory portion. When it is desired to have air pass freely into the olfactory portion, the act of sniffing is resorted to.

Variations.—The variations of the nasal chambers relate to the septum, to the turbinated bones, to the floor of the nose, and to the general subject of asymmetry.

The septum is frequently deflected in civilized races. The deflection occurs at the line of the ethmoido-vomerine suture, and is more pronounced anteriorly than posteriorly. The angulation in the septum may be so pronounced in the chamber as to permit the end of the deflected portion to be received in the opening of the maxillary sinus. The septum varies remarkably in thickness, especially in the lines of the ethmoido-vomerine suture, and at the surfaces of junction with the triangular cartilage. It is of uniform thickness at the posterior nares, where, however, the mucous membrane over it may be asymmetrically thickened.—The vomer at the base of the ethmoidal notch is subject to a peculiar form of hyperostosis, by which it is enormously thickened. With this condition are often associated an overgrowth and deflection of the superior maxilla where it enters into the composition of the nasal septum.—The vomer at the posterior nares may be deflected at its basal part. Connected with deflection of the nasal septum, and

most probably dependent upon it, is a deviation of the cartilage of the septum.

Congenital perforation of the septum is occasionally met with. To determine the fact whether a given instance of septal defect be of congenital or of acquired origin, it may be well to remember that congenital defects are apt to be multiple, and the septal opening to be associated with the presence of a hyperostosis in the roof of the mouth, asymmetry of the facial bones, or other peculiarity, while acquired defect is apt to be of syphilitic origin, or to be the result of imperfect surgical operation. Congenital defects are, as a rule, in the triangular cartilage, just in advance of the ethmoidal notch, though they may be found in the perpendicular plate of the ethmoid bone.

The turbinated bones are subject to minute variation in form. The middle turbinated bone may be greatly reduced in size, and set relatively far back in the nasal chamber.

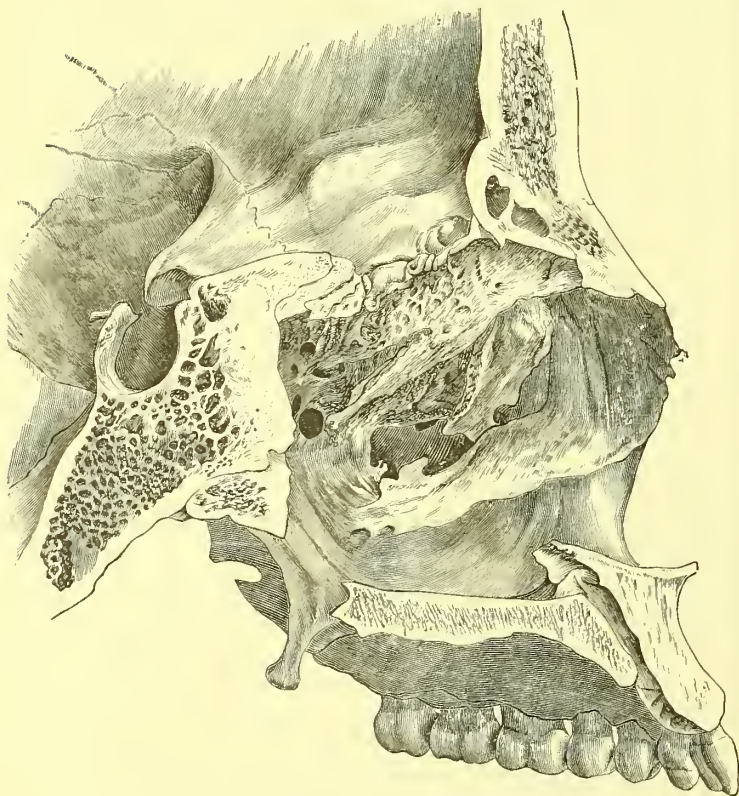
The floor of the vestibule may be raised above the plane of the nasal chamber proper, and conceal the lower border of the inferior turbinated bone (see fig. 152). The floor of the nasal chamber proper may present a shallow depression, and thus be exposed to inspection from in front of its entire length.

The chambers may be asymmetrical. The left is commonly the smaller. This contrast is particularly noticeable at the posterior nares, and is independent of the states of the nasal septum. The plane of the posterior nares, as a rule, slopes a little downward and forward.

REMARKS.—For clinical purposes, the nasal chambers may be studied under the following heads: (*a*) as divided into respiratory and olfactory portions; (*b*) as divided into the nasal chamber and the vestibule; (*c*) as divided into premaxillary, maxillary, and palatal portions; (*d*) as divided into the septum and the turbinated bones.

(*a*) *The nasal chambers as divided into respiratory and olfactory portions.* The air passing out from the pharynx, being confined to the plane of the posterior nares, is not carried up to the olfactory region, so that the odors on the expired breath are not appreciated.—When the communication between the respiratory and olfactory portions is cut off, as by swelling of the mucous membrane at the region of union of these portions, loss of smelling supervenes.—Discharge which may accumulate about the middle turbinated bone or in the upper portion of the vestibule cannot be removed by the act of blowing the nose, for the reason above assigned that the air of expiration cannot pass within the olfactory portion. The act of blowing the nose, or the process of washing out the nose by a current thrown in from the naso-pharynx, will wash out the inferior meatus with ease, provided the discharge be not inspissated, and the parts of the floor of the nose be not abnormally disposed.

Fig. 152.



An antero-posterior section of the face, exposing the lateral wall of the nasal chamber. The figure is designed to exhibit the difference in the plane of the premaxillary and the maxillary and palatal portions of the floor of the nose.

(b) *The nasal chamber as divided into a nasal chamber and vestibule.* The distinction between the nasal chamber and the vestibule is, in the main, based upon the absence of erectile tissue in the vestibule, and upon the presence of a membrane (muco-periosteum) intermediate in character between skin and mucous membrane. Diseases of the vestibule are best treated as though they were affections of the skin; while diseases of the nasal chamber are to be treated on the same principles as those of the mucous membranes generally, especially of that variety of mucous membrane lying in contact with bone.

(c) *The nasal chamber as divided into the premaxillary, the maxillary, and palatal portions.* This method of dividing the nasal chamber is convenient for clinical topography of the nose. The positions of the sutural lines of the premaxilla (see p. 134), of the maxilla, and of the palatal bones determine the points at which the boundaries of the regions may be said to be fixed. These subdivisions of the nasal chamber are effected by the production of the planes of the sutures on the roof of the mouth, vertically upward through the nasal chambers.

(d) *The nasal chambers as divided into the septum and the turbinated bones.* The morphological significance of the septum, placed as it is in the median line of the face of the embryo, with the turbinated bones lodged to its right and left sides, remains the same in the skull of the adult, notwithstanding the fact that, with cultivated races at least, the septum is deflected the greater part of its course from the median line; with this deflection ensues acquired asymmetry of the nasal chambers. One of these chambers, commonly the left, is much smaller than its fellow of the opposite side, and may be occluded, when the right chamber will be larger than is normal and possess both ossaceous and erectile structures which have undergone physiological hypertrophy. Care should be taken to distinguish between such hypertrophy and the effects of diseased action.

GENERAL CONSIDERATIONS OF THE MUCOUS MEMBRANES OF THE BODY.¹

The Mucous Membranes possess in common a cushiony, succulent, yielding surface, covered with a thick, glairy fluid termed mucus, which is secreted in great abundance by the mucous follicles, and with

numerous special fluids, such as the salivary, gastric, biliary, and intestinal fluids.

Mucous membranes are in structure closely allied to the general integument. They are composed of an epithelial covering, which usually rests upon a delicate basement membrane; these two layers forming the covering of the matrix, which is composed of fibrous connective tissue with an admixture of elastic fibres. In contradistinction to the external integument or skin, it may be looked upon as the internal integument. The epithelial layer, owing to the constant moisture maintained upon it, never assumes the horny character of the corresponding layer of the skin, and is more or less translucent. Blood-vessels are often visible on a mucous surface, and, together with rich supplies of capillaries, give it its characteristic color.

The exact *color* of mucous membrane varies with the amount of blood held within it. Thus it is pinkish or reddish in the mouth and in the nose, and, owing to the presence of numbers of minute superficial veins, dusky in the pharynx and the œsophagus. When the glandular layer is well developed, the color is yellowish-pink, as upon the anterior surface of the soft palate, or of a light pink shade where the epithelium is thick, as upon the buccal surfaces. The anterior portion of the tongue, covered as it is with filiform papillæ, yields various colors which are consistent with health, and a still greater variety of tints in disease, in which it forms an index both of the retarded and increased epithelial desquamation in the digestive tract. The prevalent color is dull red with a shade of milkiness. When the mucous membrane is in contact with cartilage, as in the orifice of the Eustachian tube and on the vocal cords, the color is pearl-like. Within the stomach, as well as in the intestine, the color is of a grayer cast. The color of the rectum resembles that of the pharynx.

After death these tints disappear from the mucous membrane, and a dull slate or gray tint predominates. The color of the mucous membrane of the stomach undergoes the greatest degree of change, owing to the action of the gastric juice.

The mucous membrane is exceedingly loose and pliable at the side and beneath the tongue, and on the floor of the mouth as it passes from the tongue to the gum line of the lower jaw. It is also very lightly applied to adjacent parts between the base of the tongue and the epiglottis, and thence to the sides of the pharynx. In the œsophagus, the stomach, and the intestine, the mucous membrane is so loosely attached to the submucous coat, that it is capable of

¹ These remarks are applicable to all portions of the alimentary, the respiratory, and the genito-urinary tract, and their consideration will be conveniently undertaken at this place as an introduction to the anatomy of the splanchnic organs.

forming plications. These are, as a rule, most marked in such parts as are emptied of food and are here transient, but in some cases they are permanent. Among the last-named plications may be mentioned the valvulæ conniventes, and the spiral folds in the cystic duct of the liver. The folds of the rectum may also be classed in this category.

Exact knowledge of the relation existing between such or similar depositions of mucous membrane, and *local peculiarities* as expressed in *diseased action*, is meagre, but is susceptible of being formulated as follows: Wherever the mucous membrane is loosely applied to subjacent parts, inflammatory effusions occur therein with ease and rapidity. Hence the sudden swellings of the face which accompany inflammatory processes within or about the cheek (see also p. 251); the enormous size of the parts and their distortion in inflammation of the tongue; the danger of inflammation at the base of the tongue and aperture of the glottis by œdema and resultant narrowing of the aperture. On the other hand, intimate union of the mucous membrane to deeper parts prevents inflammatory swelling. If these conclusions be accepted, it is evident that the grade or duration of the morbid process cannot be estimated by the amount of effusion.—It is probable that where a serous membrane such as the peritoneum covers the mucous tract it acts as a preventive to submucous infiltration.

The mucous membrane is firmly attached to the alveolar processes of the upper and lower jaws, where, by its intimate union with the fibrous tissue about the bone, it forms the *gum-tissue*, or the *muco-periosteum*, by which term is meant a membrane combining the characteristics of mucous membrane and periosteum (see p. 621). The mucous membrane presents somewhat similar features where it lies in contact with cartilage, as in the nasal septum, the free portion of the cartilage of the Eustachian tube, and the larynx, and, indeed, along the entire respiratory tract below the structure last named. The term *muco-perichondrium* is appropriately used in relation to these structures. The parts covered by muco-periosteum are nourished through the membrane itself. As bone will perish when its periosteum is removed or inflamed, so bone denuded of muco-periosteum or covered with inflamed muco-periosteum will become necrosed. (See Remarks on the maxilla and the mandible, pp. 135 and 140, *infra*; also, on the inferior turbinated bone, p. 137.) The muco-perichondrium is less exactly associated with the nutrition of carti-

lage than is the muco-periosteum with that of bones, yet in one striking example, namely, in the muco-perichondrium covering the epiglottis and the arytenoid cartilages, it is recognized that prolonged inflammatory states will excite ulceration and death of the parts beneath. Wherever mucous membrane covers bone or cartilage, it is apt to possess a less degree of mobility than upon yielding structures such as the intestine. On the hard palate, the membrane is united by small fibrous trabeculæ to the ridges of the bony surface, the interspaces being occupied with racemose glands. At the roof of the pharynx, the membrane is fixed to the fibrous tissue of the base of the skull.

Upon the soft palate, it is more firmly adherent anteriorly, where it is in contact with gland-tissue, than posteriorly, where it lies over muscle-tissue. Upon the tongue, where it constitutes the cortex of that organ, it is also closely attached.

The mucous membrane of the alimentary canal belongs to the same variety as that of the respiratory apparatus, since the latter is seen, by its relation as well as its development, to be an offshoot from the former. Sharpey has given the name *gastro-pneumonic* to this variety to distinguish it from the *genito-urinary* mucous membrane.

The gastric portion of the tract becomes functionally distinct from the pneumonic portion at the lower portion of the pharynx. Above this region all the parts, namely, the mouth and nose, are related equally to the mechanism of digestion and respiration.

THE TONGUE.

The Tongue (fig. 1, Plate XCIII.) is a symmetrical muscular organ, lying on the floor of the mouth, and designed to aid in the prehension of food. It is accessory also to the sense of taste and the production of articulate sounds. The tongue, when at rest, is of an ovoidal figure (fig. 4, Plate XCIX.), whose base is abruptly truncated. When divided transversely, it is seen to be composed of a cortical and a medullary portion.

The *cortical portion* (cortex) is complete at the dorsum and at the sides, while absent beneath. It represents the mucous membrane of the floor of the mouth, which has become thickened upon the tongue for special purposes. The *medullary portion* constitutes the bulk of the organ, and is composed of interlacing bundles of the Palato-Glossus, the Stylo-Glossus, and the Genio-Glossus muscles.

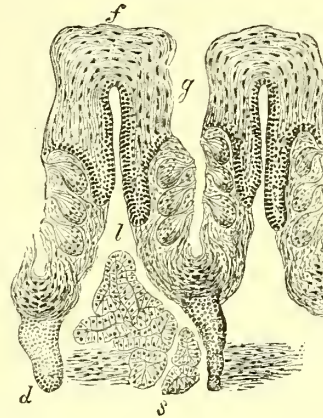
The dorsum of the tongue, which embraces the

greater part of the cortical portion, is divided into two regions by the position of the V-shaped row of rounded eminences called the circumvallate papillæ. These are placed at the junction of the posterior third with the anterior two-thirds. The *posterior third* may receive the name of the *basal third* or the *base of the tongue*; while the *anterior two-thirds* may receive the name of the *apical portion*. By ordinary inspection the basal third is concealed in the living subject, where it aids in forming the anterior wall of the pharynx. It can be readily seen, however, by the aid of reflected light. The apical third is more movable, and is, to a certain extent, protrusile. It is that portion which is seen by direct light when the mouth is opened.

The *papillæ of the tongue* are of two kinds: the true papillæ and those belonging to the fibrous investment. The *true papillæ* are the more numerous, and are distributed everywhere throughout the surface of the organ. At the sides of the tongue, toward the palato-glossal folds, they are seen as rounded, or hemispherical tubercles, arranged in ridges, which are more or less vertical, and which gradually become interrupted and diminish in length as the tip of the organ is attained. The smaller of the papillæ have been named the *secondary* papillæ, and aid in giving prominence to the *primary* papillæ.

The *primary papillæ* (true papillæ) have been variously described, but may be considered as of three kinds: the circumvallate, the capitate, and the conical.

Fig. 153.



From a vertical section through the papilla foliata of a rabbit. Magnifying power about 90. *f*, folds in transverse section with stratified pavement epithelium; at the basis of each fold are seen the taste-cells; *g*, furrows between the folds; into them open *d*, the ducts of the serous glands; *l*, lymphatic vessel in the centre of the folds.

The *circumvallate papillæ* are the largest of the series, and are placed at the boundary between the oral and pharyngeal portions of the dorsum. As the name indicates, each is distinguished by being walled in by a prominent circle of secondary papillæ. The

Fig. 154.



From a vertical section through a circumvallate papilla of a child. Magnified about 50. *a*, fold of mucous membrane surrounding the papilla itself. *p*, the fungiform papilla, showing minute secondary papillæ. Of the stratified epithelium only the nuclei of the cells are shown. At the basis of the papilla are seen the taste-cells. *s*, serous gland; its duct opens at the base of the papilla; *m*, a small section of a lobule of a mucous gland between the lobules of the serous gland; *b*, the vascular mucosa; the holes are capillary vessels cut in different directions.

papillæ vary in number from ten to twenty, and are arranged in two lines which diverge obliquely. A median groove placed behind the circumvallate papillæ has received the name of the *foramen cæcum*. It may be absent or be double. A number of racemose glands may open in or about it.

The *capitate papillæ* are small and rounded, and are scattered over the tongue without special regularity, in a measure preserving the oblique direction behind, but slightly aggregated toward the tip. It is thought that within these the tactile sense of the organ chiefly resides.

The *conical papillæ* are the most numerous. They are arranged in lines which are parallel to the circumvallate papillæ in the neighborhood of these structures, but gradually become more transverse as the tip of the tongue is approached. They are covered with hair-like extensions of epithelial cells; hence the name often given them of *filiform papillæ*. The "fur" of the tongue is due to changes in these cells or to adherent foreign matters.

Bloodvessels.—The *arteries* of the tongue are derived from the lingual branch of the external carotid. They are remarkable for their large size, compared with that of the organ which they supply, and for the limited communication between the vessels of the two sides. Hyrtl demonstrates this anastomosis at but two points: one near the position of the circumvallate papillæ, and the other toward the tip of the tongue. An insignificant superficial artery lying along the line of the raphé would be the only vessel divided by a median incision upon the dorsum. The *veins* accompany the arteries and descend to join the internal jugular vein. The branches beneath the tongue are especially conspicuous when the tip is directed to the roof of the mouth.

The extreme vascularity of the tongue has occasioned frightful loss of blood when the vessels have been opened in the course of the sloughing of cancer, as well as in non-malignant ulcerations extending into the tongue from the throat.¹ In the operation of dividing the frænum linguæ, the *ranine arteries*, by which name the abrupt terminal branches of the lingual artery are known, may be divided. Cruikshank is quoted² as having divided the frænum in a child which was discovered some time after the operation to be dead from loss of blood. An enormous coagulum was found in the stomach.

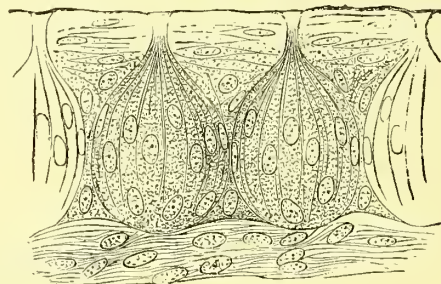
Owing to the distribution of the lingual arteries,

each to its own side, unilateral glossitis may occur. Graves¹ has recorded a typical instance of the kind occurring in a medical student. The left half of the tongue was affected, and was so enlarged that the mouth could scarcely be closed; while the right side of the organ was in all respects normal.

After an injection of a solution of perchloride of iron into an epulis growing from the gum of the lower jaw, acute inflammation of the superficial veins of the tongue has been excited. The numerous instances of rapid serous infiltration of the supra-hyoid space can be accounted for only when the course of the lingual veins is considered.²

The nerves of the tongue.—The sensory nerves are derived from the lingual and glosso-pharyngeal nerves. The lingual nerve supplies approximately the anterior two-thirds of the organ and the glosso-pharyngeal the posterior third. Some of the terminations of each of the above-mentioned nerves are associated with remarkable organs known as taste-buds (taste-cells).—The motor nerve of the tongue is the hypoglossal.

Fig. 155.



Taste-cells of the tongue.

Variations.—The tongue is subject to many interesting variations. The entire organ may be too short, and the tip of the tongue cannot be brought readily against the roof of the mouth near the incisor teeth. The organ may be larger than is normal, and protrude from the mouth, causing great deformity in the position of the lower teeth. The condition known as "tongue-tie" is implied when the tip of the tongue is held to the floor of the mouth by a short and inextensive frænum. Tongue-tie interferes with the prehensile power of the tongue, and is enumerated among the causes of stammering. The dorsal curve of the tongue normally corresponds to the curve of the under surfaces of the hard palate and of the soft palate.—It is probable that minute congenital defects in the tongue, which interfere with the easy adaptation of the tongue to the palate, may also be among the causes of indistinct articulation and of stuttering. The tongue may be asymmetrical, not only from

¹ Amer. Journ. Med. Sci., series 1, 26, 193.

² Bell, Institutes of Surgery.

¹ Dublin Hosp. Rep., iv. 43.

² Holthouse, Trans. Clin. Soc. Lond., ii. 140.

congenital causes, but from those acquired as from paralysis. Romberg¹ has described a case of unilateral atrophy of the tongue.

REMARKS.—The applications of a knowledge of the anatomy of the tongue to the study of disease are numerous and important. They will receive attention under the following heads: (a) the cortical portion; (b) the medullary portion; (c) localization of diseased action in the basal and apical portions; (d) fixation of the tongue; (e) distribution of the *fur*.

(a) *The cortical portion of the tongue* is the seat of a peculiar atrophic disease incident to syphilis, which has received the name of "bald tongue." It is recognized by the presence of smooth glossy patches which are remarkable for the absence of fur which may coat elsewhere the entire cortex. In a rarer disease—ichthyosis of the tongue—the cortical portion forms a white layer which has been compared to wet leather, or to a thin film of boiled albumen. It may be regarded as a form of epithelioma. Lingual cancer is believed by J. Hutchinson to be always of epithelial origin.—The circumvallate papillæ are often enlarged in strumous subjects.

(b) *The medullary portion.* The medullary portion, composing as it does by far the major portion of the organ, is remarkable for the ease with which it recovers from injury, and the size which it may attain in acute inflammatory conditions. In the treatment of wounds of the tongue it is well to remember that sutures are retained with difficulty. It is recommended to close the jaws firmly, so as to compel the injured organ to lie upon the floor of the mouth, and within the embrace of the sides of the inferior maxilla. In a wound of the medulla the adaptation is perfect when the tongue is thus placed.

(c) *The localization of diseased action in the basal and apical portions.* The circumvallate papillæ divide the tongue into two regions: one, comprising the anterior two-thirds of the dorsum, being supplied by the lingual branch of the inferior maxillary nerve; the other, the posterior third, by the glosso-pharyngeal nerve. The anterior region lies within the mouth, is almost without glands, and is covered by a derm-like involucre closely held to the muscle; the posterior third lies within the pharynx (fig. 7, Plate XCIX.), is rich in glands, and is loosely covered by a thin, smooth mucous membrane.

Cancerous disease always begins in the anterior portion, and only passes behind the line of the cir-

cumvallate papillæ when the disease is wide-spread, the parts directly beneath its nidus being first involved. The disposition of the lymphatic vessels easily accounts for this fact. These vessels are numerous on the dorsum of the tongue, and are especially so, according to Sappey, until the line of the circumvallate papillæ is reached, when they abruptly cease, a few only passing to the pharyngeal portion. Nearly all of them unite to form on either side a main vessel of descent, which passes vertically through the muscular structure, and joins its special gland near the anterior belly of the Digastric muscle. Though the most common course of the disease is as above given, the pharyngeal region may be involved by cancer from in front. J. H. Moore¹ divided the lingual nerve for the relief of pain from cancer in the anterior part of the tongue; the relief was permanent as far as the lingual nerve was concerned, but when the disease invaded the area of the glosso-pharyngeal nerve, the pain recurred.

The presence of large numbers of glands in the pharyngeal portion of the tongue would suggest the frequent occurrence of glandular lesions here. They are, however, rare. In those few examples of cystic disease which have been recorded, no mention is made by the writers of the strictly local character which our knowledge of anatomy would lead us to expect this disease to assume. It is, however, likely that a cyst, forming at the base of the tongue, would find less resistance toward the fatty centre of the "medulla" of the tongue than toward the pharyngeal contour; a view which would harmonize with Salter's observation, that the branches of the follicles are often lodged in the parenchyma fully one-half or three-quarters of an inch from the orifice of the gland. The glands at the base of the tongue are capable of producing a free secretion of thick mucus. The following case² is given in exemplification of this fact, and also to show how long-continued pressure may be borne in a locality noted for its resistance to slight intrusions. A male, aged sixty, had for three months suffered from an abundant secretion of tenacious mucus in the pharynx, with hacking cough, and some dysphagia. After many attempts had been made by the patient to relieve the symptoms, the recorder extracted an upper set of artificial teeth from the pharynx, where they had rested directly upon the base of the tongue.—The glands are frequently hypertrophied in persons disposed to tuber-

¹ Klinische Ergebnisse, Berlin, 1846; also J. H. Bennett, Clinical Lectures on the Principles and Practice of Medicine, fig. 122.

¹ Proc. Medico-Chir. Soc., 1862.

² J. Paget, Med. Times and Gaz., Jan. 18, 1862, 59.

cular disease, and are at times the chief cause of the irritative cough so noticeable in the first stage of phthisis.¹

Fibrous tumors are of rare occurrence in this locality, but tend to be developed toward the base of the tongue. W. Hunt operated on a girl of sixteen, the basal portion of whose tongue was entirely occupied by a fibrous tumor. The patient died suddenly on the third day.

In acute glossitis the tongue may become enormously swollen, and life be threatened by pressure of the organ upon the larynx.

According to Erb, bilateral paralysis of the tongue is a characteristic feature of progressive bulbar paralysis. Incoördinated movements of the tongue are seen in chronic alcoholism, in other adynamic states as the typhoid condition, in some forms of chorea, etc. The prehensile portion, being supported to a less degree than is the basal, exhibits these changes almost exclusively.

(d) *Fixation of the tongue.* The tongue is the most movable of any part of the oral and of the hyoid apparatus. The chief attachment of the organ is to the hyoid bone, but the Genio-Hyoid muscles are powerful tractors in maintaining the tongue in contact with the inferior maxilla. When these muscles are divided, as in the operation of amputation from beneath, the tongue falls backward and overlaps the glottis. The same position of the tongue is assumed in asphyxia and in some of the sequelæ of whooping-cough.

(e) *The distribution of the "fur."* The "fur" on the tongue is either confined to the basal third or to the anterior two-thirds of the dorsum. The basal third lies within the pharynx, and is covered with tenacious "fur" in many diseases of the pharynx and larynx, while the "fur" of the anterior two-thirds pertains more particularly to general states of the health. When the "fur" is confined to one side of the oral portion of the tongue, it may be due to local disease, as in an affection of the lingual branch of the fifth nerve, or to the irritation excited by a fragment of a tooth, etc.

¹ The tongue may be divided into an apical and a basal portion, which division answers pretty nearly to the division above adopted. These two portions in many animals are sharply separated by a difference in the plane of the upper free surface, the plane of the basal portion being higher than that of the apical. The apical portion is the *prehensile portion* in animals of the ruminant and edentate types, and in man is the portion which chiefly relates to the formation of many consonants.

THE ALVEOLO-LINGUAL GROOVE.—When the tongue is at rest, there extends between it and the gum of the lower jaw a groove, which has received the name of the *alveolo-lingual groove*. Beneath the tip of the organ, this space is incompletely divided by the frænum. The base of the groove is distinguished by its whitish color, and has commonly upon its surface a vein whose thickest portion is directed from behind forward.

The Mylo-Hyoid muscle lies immediately beneath the surface, and, from its analogy to the Buccinator and Constrictor muscles of the pharynx, may be considered a submucous structure. The mucous membrane is but loosely attached to it. On either side the groove is marked by an irregular fimbriated line answering to the position of the sublingual salivary glands. Beneath the tongue on either side is seen the opening of the duct of the submaxillary salivary gland, which forms a little elevation sometimes called the *sublingual caruncle*. The alveolo-lingual groove is best developed in the negro.

REMARKS.—The duct of the submaxillary gland (duct of Wharton) may be occluded by calculi, or, rarely, by foreign bodies. By the accumulation of saliva in the duct from these causes, a large *retention cyst* (ranula) may form. Mr. Jessop¹ mentions the case of a male, aged twenty-four, in whom the calculi had been noticed in the mouth for a year. Suddenly a swelling made its appearance, which so rapidly increased in size as to form by the fourth day a mass as large as a hen's egg. The patient suffered from pain in the neck, and had difficulty in breathing and swallowing. Two calculi, each the size of a pea, were removed from the right submaxillary gland, when a gush of retained saliva followed, and the symptoms subsided. The other conspicuous lesion of this region is cystic tumor. This disease has long been considered the result of obstruction of Wharton's duct; but, as shown by C. D. Weber,² is more frequently developed from the synovial sac, described by Fleishman as lying close to the frænum, on the outer side of the Genio-Glossus muscle, and beneath the mucous membrane of the tongue.—The pressure on the hyoid apparatus by a large cystic tumor is often sufficient to induce apnoea. Bransby Cooper narrates a case in which a prompt opening of the cyst was required to save the life of the patient.—Another form of cystic tumor, distinct from the foregoing, lies deeper than

¹ Br. Med. Journ., 1871, 120.

² Virchow's Archiv, vi. 27.

Fleishman's cyst, and, in developing, makes little or no impression within the alveolo-lingual groove; but, instead, expands within the supra-hyoid space.¹—Erichsen² records a case in which he found collections of pultaceous caseous matter, probably sebaceous in character. Bryant³ believes the sebaceous variety to be always congenital. Two cases came under his observation, both occurring in persons under twenty years of age.—The sublingual fold is often excessively enlarged as a complication of glossitis.—W. F. Clark⁴ narrates a case in which the symmetrical enlargement of the sublingual folds, due to the irritation of a carious tooth, simulated cystic tumor. A horseshoe-shaped swelling was formed around the free portion of the tongue.

THE SALIVARY GLANDS.

The Salivary Glands compose a system of racemose glands, six in number, which are arranged in pairs, and which open into the mouth.

The salivary glands are—

The Parotid.

The Submaxillary.

The Sublingual.

THE PAROTID GLAND.

The Parotid Gland (fig. 6, Plate XCIX.) is the largest of the salivary glands. It is lodged in the space between the lower jaw and the ear, which is hence known as the bed of the parotid gland. It extends a short distance downward below the lower jaw, forward over the posterior border of the Masseter muscle, backward over the Sterno-Cleido-Mastoid muscle, and inward as far as the styloid process. The gland is smaller and more fixed above, larger and more movable below. It is covered by the compact parotido-masseteric fascia, which prevents the form of the gland from being discernible through the skin.

The duct of the parotid gland, or the duct of Steno, is about two-and-a-half inches long, and a line in diameter; it extends forward, about eight lines below the zygomatic arch. It crosses the anterior border of the Masseter muscle, and terminates by penetrating the cheek opposite the first or second molar tooth.

The gland embraces the external carotid artery as it ascends to terminate in the temporal and internal maxillary arteries.

The facial nerve crosses in its substance from before backward, and the auriculo-temporal branch of the fifth nerve ascends through it. Two lymphatic glands, each about the size of a pea, lie at the upper border, and one at the lower border. The weight of the gland is from five to eight drachms.

Variations.—A separate mass of the parotid gland, commonly of the size of an almond (*socia parotidis*), may be found lying at the anterior border of the Masseter muscle. The parotid duct infrequently divides at the anterior border of the gland into a slight upper and a stout inferior branch.

Bloodvessels and Nerves.—The bloodvessels of the parotid gland are derived from the external carotid and the facial arteries. The gland receives nerves from the auriculo-temporal branch of the fifth nerve and from the anterior branch of the first cervical ganglion of the sympathetic system.

REMARKS.—In health the parotid gland cannot be said to have a well-defined capsule. But in diseased conditions a capsule is formed which enables the operator to enucleate the gland with comparative ease—the situation of the gland, and the important vessels traversing it, however, at all times making this a serious undertaking.

It is important for several reasons to remember the bearings of the parotido-masseteric fascia. A swelling forming beneath it, as in mumps, is prevented from appearing on the surface, and is seen to best advantage upon the neck below the angle of the jaw,¹ or, more rarely, within the pharynx, where it interferes with deglutition and the depression and elevation of the lower jaw. Pus, forming beneath the fascia, gives little or no evidence of its presence. If a swelling due to this cause be present, it is of a flattened form.² Sometimes the fluid, not finding vent externally, passes posteriorly, and finds exit into the external auditory meatus.³

When a tumor is removed from over the parotid gland, it follows that the parotido-masseteric fascia is destroyed: and should the growth recur, it will from this fact be more conspicuous upon the face, since its development no longer is resisted by the fascia.⁴

The free inferior lobe of the parotid may be the seat of separate diseased action. Growths from this portion of the gland may affect the pharynx indirectly by pressure, or directly by transmitted diseased action.

¹ According to Monteggia (Malgaigne, Chir. Anat. 1, 455), the swelling of the parotid gland in inflammation may press the condyloid process forward, thus simulating dislocation of the lower jaw.

² Hyrtl, Topog. Anat., 1, 331.

³ Velpeau, Chir. Anat., 1, 26.

⁴ Hyrtl, Topog., loc. cit. 338.

¹ Bell, Principles of Surgery.

² Ibid.

³ Med. Times and Gaz., 1860.

⁴ Davies's Surgery, 220.

It has been shown by Allan Burns that a sacculated condition of the lobe, originating behind the lower jaw, may spread downward and laterally upon the neck.¹

Aneurismal conditions of the vessels of the gland may produce symptoms of suffocation, and give rise to pulsating tumors in the region of the tonsil.

The superficial portion is rarely the seat of cancer. The disease almost invariably begins in the deep portion of the gland, and early involves the facial nerve by pressure.

Cystic tumors, on the other hand, may be found within the superficial portion only. Fergusson has formulated a good rule on the subject of parotid tumor: If the skin can be freely lifted from over the tumor, it is probable that the tumor may be removed, whether cystic or otherwise, without necessitating the removal of the entire gland; but the skin, if tense, infiltrated, and fixed, indicates that the entire gland is involved.

Tumors may arise within that portion of the gland overlying the Masseter muscle; these may be due to engorgement of the *socia parotidis* or be the result of occlusion of one of the accessory ducts. They are at first freely movable, painless, and excite at times an increased flow of saliva. It is important to discriminate between these swellings, enlargements of the lymphatic glands of this region, and incipient enchondromata. The tumors last named are elastic, and resemble small cysts, for which they have often been mistaken.

Inflammatory obstruction of the parotid duct will cause intumescence of the gland, yielding unusual symptoms. Since the duct of Steno cannot be traced deep within the body of the gland, the swelling will be confined to the superficial portion. The mass differs from other swellings of the region by the presence of a ridge, seen also within the mouth, placed between the Masseter muscle and the cheek. There is sometimes little or no pain, at others a sense of soreness only. This rare condition was first accurately described by Allan Burns (*loc. cit.*).

A fatal case of abscess of the parotid gland involving the temporo-facial vein has been recorded by Murchison.²

THE SUBMAXILLARY GLAND.

The Submaxillary Salivary Gland (fig. 6, Plate XCIX.) is about a third smaller than the parotid, and of a subrounded shape. It lies entirely within the

neck, between the Digastric muscle below and the lower jaw above. In part it is received within a depression on the lower jaw, beneath the oblique line, and in part rests upon the Mylo-Hyoid muscle. The lobules of the gland are somewhat more pronounced than those of the parotid, and are less compactly arranged. The gland tissue accompanies the duct (here called the duct of Wharton) as it passes backward to the border of the Mylo-Hyoid muscle, and winds round it. The duct as it lies upon the upper surface of the muscle has the sublingual gland above it, and terminates in the mouth near its fellow by a prominent projection at the side of the lingual frænum.

Bloodvessels and Nerves.—The submaxillary gland is supplied by branches of the facial and lingual arteries, and by nerves from the submaxillary ganglion.

Variations.—The gland may partially surround the lateral border of the Mylo-Hyoid muscle. Separate lobules may be attached severally to the duct of Wharton beyond the limit of the main gland.

For remarks see Alveo-Lingual Groove.

THE SUBLINGUAL GLAND.

The Sublingual Gland is a convenient name for a group of glands lying beneath the mucous membrane of the floor of the mouth, and constituting the ridge which extends from the outer side of the sublingual caruncle, about an inch and a half, to the first molar tooth. The separate glands are from six to eight in number, and their several ducts are known as the ducts of Rivinus. Two or three of the smaller glands may unite to form a single duct. The most noteworthy of these ducts is one running toward the sublingual caruncle, and sometimes tributary to the duct of Wharton, called the duct of Bartholin. The glands lie above the Mylo-Hyoid muscle, and the duct of Wharton rests upon the Genio-Glossus muscle.

Bloodvessels and Nerves.—The arterial supply of the gland is derived from the submental and sublingual arteries. The nerves are derived from the submaxillary ganglion.

THE TEETH.

The Teeth (figs. 1, 2, 3, 5, Plate XCIX.) are special structures developed from the mucous membrane of the mouth, but lodged in the jaws, and designed to cut, to tear, and to grind the food. They are of four kinds—named in order from the front to the back of the jaws—the incisors, the canines, the bicuspids, and the molars; and of two sets, the permanent,

¹ Surg. Anatomy of the Neck, Edinburgh, 1823, 303.

² Trans. Path. Soc. London, 1859, x, 99.

and the deciduous (milk teeth, temporary teeth). The permanent teeth are thirty-two in number, four incisors (two central and two lateral), two canines, four bicuspids, and six molars in each jaw. The deciduous teeth are twenty in number, four incisors, two canines, and four molars in each jaw.

The teeth are so arranged in pairs that on each side of the upper and of the lower jaw one or more examples are found of the incisor, canine, bicuspid, and molar types.

The teeth of the permanent set will be first described.

Fig. 156.

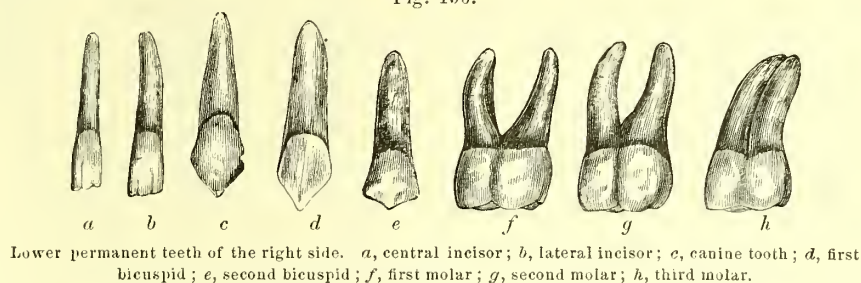
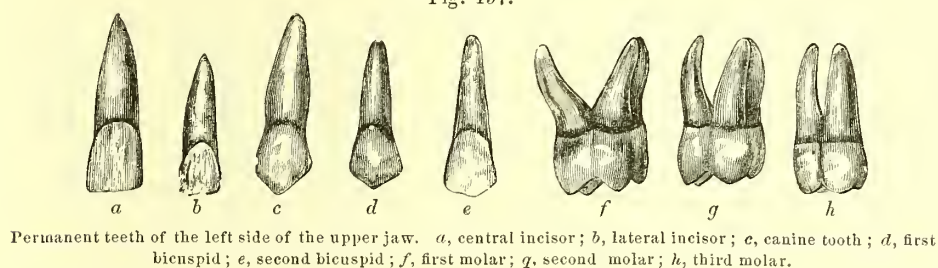
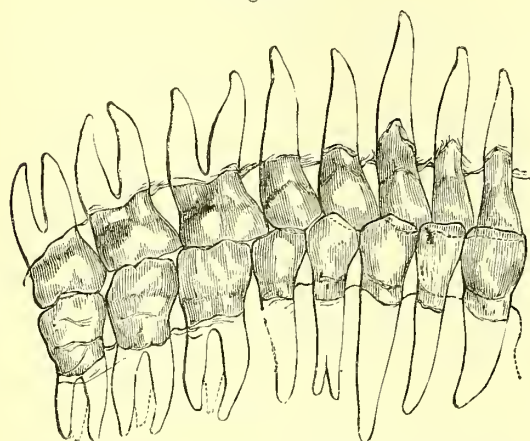


Fig. 157.



• *General Characters of the Teeth.*—Each tooth presents for examination a crown or body, a root or fang, and a neck. The crown is the erupted portion, and is covered with enamel. The root is imbedded in the

Fig. 158.



alveoli of the jaws, and is covered by periosteum (odonto-periosteum, periodontium). The neck is the slightly constricted portion of the tooth which lies between the crown and the root. It is ordinarily concealed from view, but may become exposed in persons past middle life.

THE INCISORS.

The Incisors (figs. 159–161), or cutting teeth, are eight in number—four in each jaw. They closely

Fig. 159.

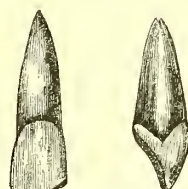


Fig. 160.

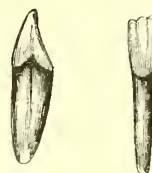


Fig. 161.—Lateral incisor lower jaw, front and side views.

Fig. 162.—Canine of the upper jaw, front and side views.

Fig. 161.

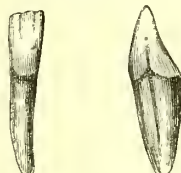
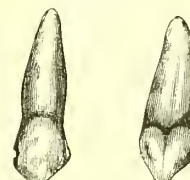


Fig. 162.



toward the cutting edge, and elongated roots, which are compressed from side to side. The median border

of the crown is nearly straight, the lateral (outer) border is slightly convex, and, in the upper jaw, directed obliquely downward and outward, the peculiarity last named being best seen in the superior lateral incisor. The cutting edge of the newly erupted crown is ordinarily marked by three minute serrated inequalities, which are soon lost, and the anterior surface by from one to three faint longitudinal grooves. The general contour of the edge of the fully developed tooth is slightly curved (laterally) downward; a peculiarity best seen in the lateral tooth. The posterior surface ordinarily exhibits a triangular concavity occupying about two-thirds of the entire surface. Between the apex of this space and the neck of the tooth there is a rounded prominence, and at the sides are well-defined ridge-like borders which are continuous with the median and lateral contour-lines.

THE CANINE TEETH.

Fig. 163.



Canine tooth of the lower jaw, front and side views.

The Canine teeth (figs. 162, 163) are four in number—two in each jaw. They are the largest teeth in the series. The crown projects slightly below the other teeth in the upper jaw, and above them in the lower. The root, which is twice as long as the crown, is deeply imbedded in the structure of the superior maxilla. The general form of the crown is conical, with a triangular depression posteriorly, which is smaller than the similar space on the incisor. The lateral walls also are thicker than in the incisor, and the basal prominence is larger. The root is grooved upon its lateral surface. The cutting edge is composed of two oblique converging surfaces of which the median is the smaller.

The term “eye-tooth” is often given to the superior canine. Its application is supposed to be due to the fact that inflammation of the root may lead to inflammation of the appendages of the eye.

The lower canine tooth is sometimes called the “stomach tooth.”

THE BICUSPID TEETH.

The Bicuspids (premolars) (figs. 164–167) are eight in number, four in each jaw. As the name implies,

they present two cusps or prominences, separated by a deep transverse fissure on the grinding surface of the crown. The outer (buccal) cusp, the larger of

Fig. 164.

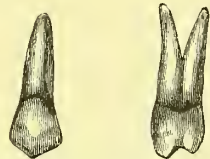


Fig. 164.—First bicuspid of the upper jaw, front and side views.

Fig. 165.

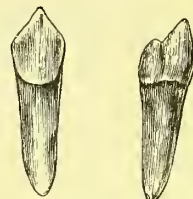


Fig. 165.—First bicuspid of the lower jaw, front and side views.

the two, is more or less tri-hedral; the inner (palatal) cusp is conical. The two are united at the median

Fig. 166.

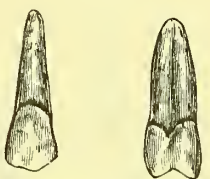


Fig. 166.—Upper first bicuspid, front and side views.

Fig. 167.

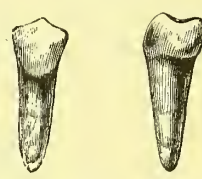


Fig. 167.—Second bicuspid of the lower jaw, front and side views.

and lateral borders by a ridge, the median border being the more robust. The root is compressed laterally, and is grooved on either side.

THE MOLARS.

The Molars (grinders) (figs. 168–170) are twelve in number, six in each jaw. They are of quadrilateral form and diminish gradually from the first to the third. Each crown presents four cusps, of which the antero-

Fig. 168.



Fig. 169.



Fig. 170.



Fig. 168.—First molar of the upper jaw.

Fig. 169.—Third molar of the upper jaw.

Fig. 170.—Second molar of the upper jaw.

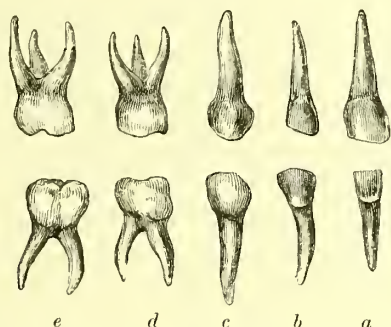
internal (medio-palatal) is the largest, and the postero-internal (latero-buccal) commonly the smallest. In the superior molars the antero-external (medio-palatal) and the postero-external (latero-buccal) apparently blend, forming an oblique ridge on the grinding surface of the crown separating the remaining cusps. The median border of the grinding surface is limited by a ridge uniting the two anterior (median)

cusps. The buccal and lateral sides of the crown are marked by faint fissures which are continuous with the sulci on the grinding surface, while the median and palatal sides are unbroken. The roots are three in number, of which the inner or palatal is the largest and most divergent, the two outer or buccal roots being as a rule parallel with each other and united at the crown.

The last molar or wisdom tooth is the smallest of the three, and exceedingly irregular in form.

As a rule the two anterior (median) cusps and the median ridge are constant, but the two remaining cusps are apt to be small and the postero-external (latero-buccal) may be absent. In all the molars this last cusp is the smallest, and may not reach to the level of the others. The roots of the wisdom tooth may be entirely confluent and somewhat deflected from the axis of the crown. In the inferior molars the cusps are of nearly equal size, and separated by a deep cranial sulcus. The crowns are more oblong from the median to the lateral border than is the case with the superior molars. The crowns are two in number and compressed medio-laterally.

Fig. 171.



The deciduous teeth of the right side in the upper and the lower jaws. *a*, central incisors; *b*, lateral incisors; *c*, canine and stomach teeth; *d*, first molars; *e*, second molars.

THE DECIDUOUS TEETH.

The Deciduous Teeth (figs. 3, 5, Plate XCIX. figs. 171-173) (milk teeth, temporary teeth) are twenty in number. They resemble in their general features those of the permanent set, though at the junction of the neck and crown the enamel is apt to have a slightly bulging appearance, which is best seen in the molars. The canines are relatively shorter, while their crowns are broader than their successors. In the molars the ridges are often developed at the expense of the cusps. In the bicuspid tooth the ridge uniting the cusps on their median border frequently assumes the form of a trenchant fold of enamel.

81

Fig. 172.



Fig. 172.—Upper second deciduous tooth with four roots.

Fig. 173.



Fig. 173.—Lower second deciduous molar with three roots.

Variations.—The teeth are very variable in form, so that it is difficult to frame any description which will not be open to exception. A few general principles may be of use in enabling the student to identify readily any departure from the above outline description.

(1) For every cusp there is a tendency to form a distinct root.

(2) All cusps tend in variation to assume the conical form. A tooth with a single cusp, as the incisor, may be said to be a cone compressed from before backward; and a canine tooth, a cone slightly excavated posteriorly.

(3) The inflections between the conical crown and its basal eminence described in connection with the incisors and canine teeth are sufficient to define every possible modification of form in the crowns of these teeth.

(4) This basal eminence in the human tooth is of the same value as the *cingulum* of the teeth of some quadrupeds.

(5) The incisor and canine teeth are composed respectively of a single modified cusp and an insignificant basal ridge or *cingulum*.—A bicuspid tooth is composed of a primary cusp, and a larger cingulum, which, however, never attains the size of the primary cusp. In the bicuspid tooth the cingulum enters upon the grinding surface, where it is functionally active, and where it may receive the name of a second cusp.—The molar tooth retains the two cusps of the bicuspid tooth, and in addition secures a third placed upon the outer or buccal side of the others. Upon the palatal side (opposite the latter), is a large cingulum, which is almost coequal with the true cusps, but enters less completely upon the grinding surface. These features distinguish the first and second superior molars. The third superior molar or wisdom tooth resembles closely a bicuspid in the general absence of the cingulum and in the retention of the molar cusp in a comparatively active condition. The lateral surface of the crown of a wisdom tooth is apt to present no sulci, thus resembling a similar surface of the bicuspid tooth.

(6) In the lower jaw all four of the conical points of the grinding surface are engaged in the trituration of food. If any additional conical eminences be present, they almost invariably appear upon the buccal surface.

(7) The union of the inner and outer cusps of a bicuspid tooth by a ridge, and the subsequent appearance of this ridge in uniting the anterior pair of cusps are not characteristic of the human teeth, but are best seen in the teeth of the East Indian monkey (*Semnopithecus*) and in those of the baboon (*Cynocephalus*). Occasionally in supernumerary incisor teeth

the cingulum may assume the characters of a eusp, in which event the incisor can be distinguished with difficulty from a bicuspid tooth as far as the crown is concerned.

The roots of the upper molars may be four in number. The roots of the upper molars tend in variation to diverge, while those of the lower molars tend to converge.

Eruption of the Teeth.—The deciduous incisors, as a rule, are erupted before the large fontanel closes. Thus the first incisor appears at the age of six or seven months, and the large fontanel is closed at twelve. The fontanel is entirely ossified at the third year.

*Development.*¹—The teeth are developed from the oral mucous membrane in the following manner: In the seventh week (fortieth to forty-fifth day) a faint groove appears upon the surfaces of the jaw in the position of the future dental arch. Owing to the increased growth of the epithelial cells along the sides of the groove the membrane appears slightly swollen. Coincident with this a fold of the deeper layer of the epithelium carrying with it the layer of cylindrical cells (the Malpighian layer) descends with the groove and occupies its entire length. It is, in a word, a distinctly specialized structure growing from the oral epithelium in the same manner as glandular organs arise. Thus lodged, it expands at its free or lower portion, and becomes thinned at its upper attached portion. The former becomes concave beneath to adapt itself to a conical projection that is seen growing upward from the embryonic tissue of the jaw. The epithelial growth is now divided transversely into a number of separate processes, each of which is attached to the side or top of the groove by a distinct stem. At this time each involution might be compared to a bell-glass with a long handle or to an inverted letter A (Tomes).

The groove is now closed above by the oral mucous membranes, and no trace remains of the peculiar process of involution by which a fold of epithelium has been imprisoned beneath. The groove thus becoming obliterated and each papilla being in relation to its own enamel organ, the remainder of the enamel-riband disappears, and membranous partitions separate the sacs of the developing teeth from one another. These partitions by their ossification form the future alveoli.

This process of epithelium is the germ of the enamel, and is hence called the *enamel-organ*. The papilla to which it is adapted contains the germ of the dentine, and is called the *dentine-organ*.

The enamel-organ adapts itself accurately to the growing dental papilla, defines the crown of the future tooth by terminating at the neck, and firmly embraces the papilla by a well-defined constriction. It is thickest over the apex of the dentine-organ, but becomes thinner as it approaches the base.

The closure of the follicle is coincident with the absorption of the stem of the enamel-organ, which for the remainder of the development is nourished by the wall of the follicle.

The upward growth of the dental papilla and its hood causes absorption of the stem of the latter, and from the time of its disappearance the enamel-cup is called the enamel proper of the tooth, and no trace of its peculiar origin is seen. The dentinal structures form successively from without inward in the papilla, thus narrowing the use of the soft structures, and serving to limit the future pulp-chamber. The roots of the teeth grow as the papilla ascends, and receive their cemental coverings by changes in the wall of the sac, which are almost identical with the process of the development of bone from membranous structures.

Development of the permanent teeth.—At the sixteenth week a second diverticulum similar in kind to the first passes downward to the inner side of the deciduous tooth-sac. The sixth-year-molar is *primary*, i. e., is a bud-like growth; it arises from the epithelium from the same layer which yields the first enamel-organ germ. At the third month the twelve-year-molar bud arises from the neck of the enamel-organ, thus constituting a *secondary* outgrowth, while at the third year the bud-like growth which evolves the eighteen-year-molar, thus in its turn constituting a *tertiary* outgrowth, takes its origin.

Structure of the enamel-organ.—The enamel-organ consists of three layers: first, the internal epithelium, which forms the enamel proper of the perfected tooth; second, an internal epithelium, which is composed of simple rounded cells and is absorbed during the process of eruption; and a third or intermediate layer (called the *stratum intermedium*) which serves the purpose of nutritive substratum to the other two (Tomes). It is composed of cells having distinct nuclei and ramified processes, which latter freely anastomose. The enamel-organ is smooth where it covers the dentine-organ, but is indented by numerous papillary projections on its outer surface.¹

The dentine arises from calcification in the interstices of the cells—forming the intertubular substance. This is not a negative process, but the result of certain changes in the cells by which a special

¹ See also p. 60.

¹ LeGros and Magitot, Journ. of Anat. et Phys. 1881.

substance is thrown out and excites the intercellular matrix to appropriate lime-salts from the blood. The cells themselves form the elongated and branched tubules.

The cementum differs from the enamel and dentine in deriving the material for hardening directly from periosteal vessels. According to LeGros and Magitot, the external portion is thin, rather dense and opaque, and retains a fibrous, laminar, felt-like arrangement of its fibres. The internal portion is thick, soft, and transparent, and is made up of nascent connective tissue. Over the surface of the enamel-organ the wall is vascular, and forms a number of villoid processes which project into the external epithelium. (Waldeyer.)

The following table has been drawn up from the data furnished by LeGros and Magitot: At the seventh week of development are formed the beginnings of the enamel-organs. At the ninth week traces of the dentine-organ. At the fifteenth week the epithelial bud begins to be transformed into the enamel-organ. At the sixteenth week the follicle is closed, and the mucous membrane is independent of it.

REMARKS.—The teeth may be changed in position by steady pressure. Tumors will thus displace teeth. Enlarged states of the tongue will turn the crowns of the teeth in the direction of the lines of pressure. A similar malposition results from a premature union of the two halves of the lower jaw, the tongue being of normal size. The teeth may be distorted by pressure of a nævus or other tumor.¹ Lack of proper development of the superior maxillæ contracts the dental arch, and the teeth assume irregular positions. The act of thumb-sucking in a child will spread the superior dental arch and distort the roof of the mouth.

Teeth are often the seat of hyperostosis of the roots. In the lower jaw suppuration about the roots of a tooth may involve the connective tissue of the suprahyoid space. As the result of acute periodontitis and subsequent inflammation of the cancellous structure of the inferior maxilla, suppurative cellulitis of the structure of the floor of the mouth and of the tongue may ensue and has infrequently proved fatal.

THE PHARYNX.

The Pharynx (fig. 7, Plate XCIX.) is that muscular pouch which is controlled by the Constrictor muscles. It extends from the base of the skull to the cricoid cartilage, and serves to unite the mouth and nasal cavities with the œsophagus and the larynx.

As observed in the dissected subject, the pharynx is defined posteriorly and laterally by the Constrictor muscles (figs. 1, 2, Plate XLV., p. 260), superiorly by the fibrous tissue at the base of the skull. Inferiorly the pharynx is narrowed, and, as already mentioned, is continuous with the œsophagus and the larynx. The anterior border of the pharynx corresponds to an imaginary plane which unites the two pterygo-maxillary ligaments, *i. e.*, at the anterior limits of the Superior Constrictor muscle.

The pharynx is five and a half inches long, two inches wide at its widest part, and about an inch wide at its narrowest part. The mucous membrane is in health soft, smooth, flexible, and of a darkish red color.

The pharyngeal fascia.—The pharyngeal fascia (pharyngeal aponeurosis) is a fibrous membrane which extends downward from the base of the skull in the substance of the posterior wall of the pharynx. It is at first thick, but soon becomes thin, and is finally lost at about the line of the junction of the middle with the upper third of the pharynx. A second fascial extension, which serves to strengthen the lower portion of the pharynx, extends from the hyoid bone toward the tongue.

Zaufal¹ describes a division of this fascia (*plica salpingo pharyngea*) which extends from the cartilage of the Eustachian tube to the fascia in the posterior wall of the pharynx. It is held by S. Moos to be a result of diseased action.

The region between the pharynx and the vertebral column is occupied with a quantity of loose, glairy connective tissue which enables the movements of the pharynx to take place (notably the constriction of its muscles) without friction.

The pharynx is divided into three portions—

The Naso-pharynx,
The Oro-pharynx,
The Laryngo-pharynx.

The Naso-pharynx (retro-nasal portion of the pharynx) is a space which answers to the posterior prolongation of the nasal chamber. That is to say, the lateral wall of the naso-pharynx is about in the plane of the corresponding wall of the nasal chamber; so that the plane of the upper surface of the soft palate answers pretty nearly to that of the floor of the nose. It extends from the basilar process of the occipital bone to the soft palate and to an imaginary line drawn thence backward to the vertebral column.

¹ Bryant, Treatise on Surgery, 198.

¹ Archiv f. Ohrenheilk., xv. 1879, 96.

Defining the anterior wall of the naso-pharynx are the posterior nares and the posterior free edge of the vomerine septum. At the sides are the openings of the Eustachian tubes. On either side, extending obliquely from the lower borders of the tubes to the soft palate, is a fold of membrane covering the Levator Palati muscle known as the *salpingo-palatinal fold*. Between the orifice of the Eustachian tube on each side and the posterior wall of the naso-pharynx is a depression, chiefly defined by the inward (pharyngeal) projection of the cartilage of the Eustachian tube, known as the *fossa of Rosenmüller*. Hanging from the roof of the chamber is the so-called *pharyngeal tonsil*, which is a sessile collection of lymphoid bodies. The naso-pharynx is about one-and-a-half to two inches in height and from eight lines to one inch in width.

The Oro-pharynx (fig. 7, Plate XCIX.) is less constant in form than the preceding. The chamber narrows below where it is continuous with the laryngo-pharynx. The oro-pharynx extends from the inferior border of the soft palate (and its produced plane) to the level of the cornu of the hyoid bone and to the parts extending thence backward on that plane. Upon the lateral wall lies the tonsil, and behind the tonsil, extending from the soft palate to the lower part of the pharynx, is a conspicuous fold over the Palato-Pharyngeus muscle, named from its situation the *palato-pharyngeal fold* (posterior half arch). In front of the tonsil is a second fold, much smaller than the foregoing, which is the *palato-glossal fold* (anterior half arch), and which answers to the position of the Palato-Glossus muscle. The space between these folds on the side of the pharynx, and occupied by the tonsil, is called the *tonsillar space*; that between the two tonsils, the *inter-tonsillar space*.¹ The space between the palato-glossal folds is the *oro-pharyngeal aperture*; that between the

palato-pharyngeal folds, the *naso-pharyngeal aperture*. The posterior free edge of the soft palate forms at once the upper margin of both the preceding apertures.

The Laryngo-Pharynx extends from the level of the greater cornu of the hyoid bone to the lower border of the cricoid cartilage. It is defined in front by the basal third of the tongue.

Bloodvessels.—The arterial supply of the pharynx is derived from the ascending pharyngeal branch of the external carotid and the ascending palatine branch of the facial artery; it includes also small twigs from the internal maxillary.

The veins form a plexus which empties into the internal jugular vein, though some are bubulary to the occipital veins. Luschka recommends cupping the nape of the neck to relieve pharyngeal congestions. The same writer¹ speaks of frequently finding varicose conditions (with contained concretions) of these veins. Often some of the veins of the soft palate and the interior of the pharynx are visible on inspection of the parts in the living subject.

Nerves.—The nerves are derived from the pharyngeal plexus and branches of the pneumogastric nerves, and the sphenopalatine ganglion. The sensibility of the naso-pharynx is much lower than is that of the oro-pharynx or that of the laryngo-pharynx. A foreign body may be retained in the naso-pharynx without exact sensations as to its locality. The sensibility of the laryngo-pharynx is more highly developed than that of any other portion of the pharynx.

The inferior portion of the pharynx receives branches from the laryngeal nerves. The pharyngeal branch of the superior laryngeal nerve forms upon the surface of junction of the larynx and pharynx (recessus pharyngo-laryngeus, Luschka) a fold of mucous membrane which has been named by Hyrtl² the *plica nervi laryngei*.

¹ The author proposed these terms in a memoir entitled "The Soft Palate in Health and Disease," Trans. Am. Med. Assoc., 1872, 537.

¹ Schlundkopf, Tübingen, 1868, 113.

² Lehrbuch der Anatomie, 657.

EXPLANATION OF PLATE XCIX.

- Fig. 1. The permanent teeth of the upper jaw in position, seen from beneath.
 Fig. 2. The permanent teeth of one side of both the upper and the lower jaw.
 Fig. 3. The deciduous teeth of the upper jaw, seen from below.
 Fig. 4. The oral aspect of the soft palate and related parts.
 Fig. 5. The deciduous teeth of the lower jaw.

- Fig. 6. The Parotid and submaxillary salivary glands in position.
 Fig. 7. The pharynx, represented as opened from behind in order to display the naso-pharynx, the base of the tongue, and the larynx. A portion of a glass-cylinder, which has been placed in the œsophagus to distend it, is seen at the lower part of the figure.

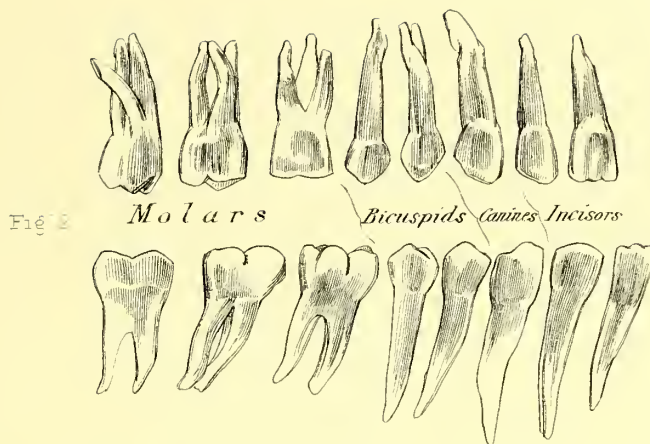
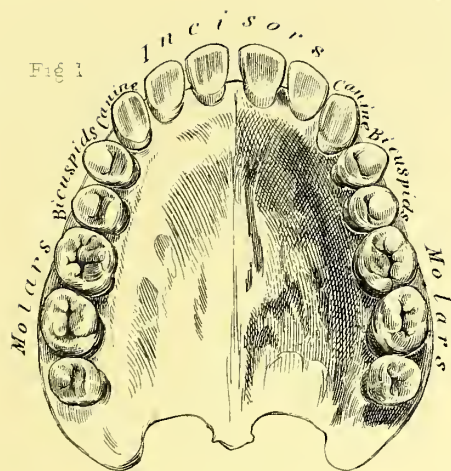


Fig. 4.

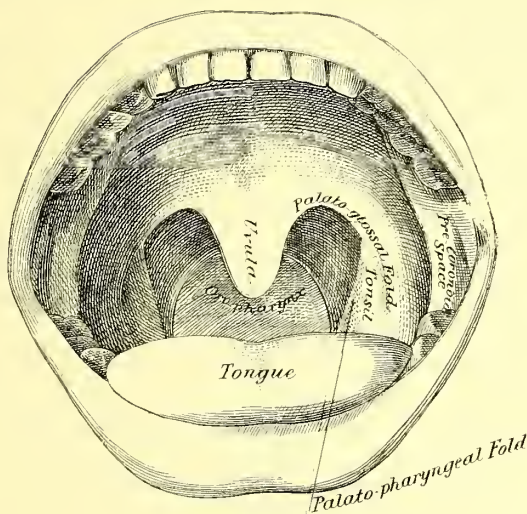
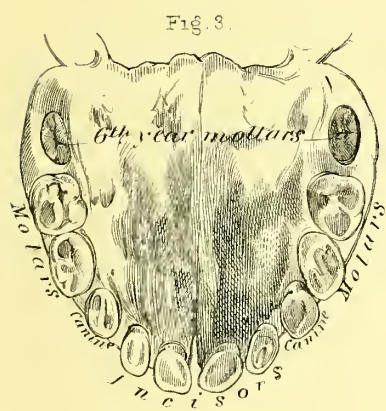


Fig. 5.

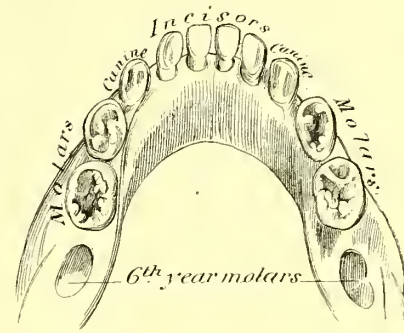


Fig. 7.

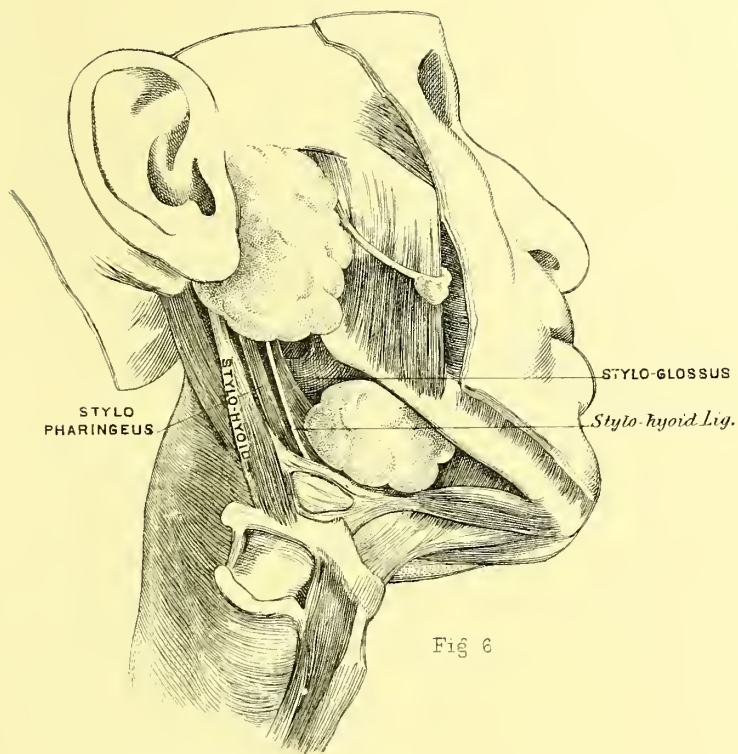
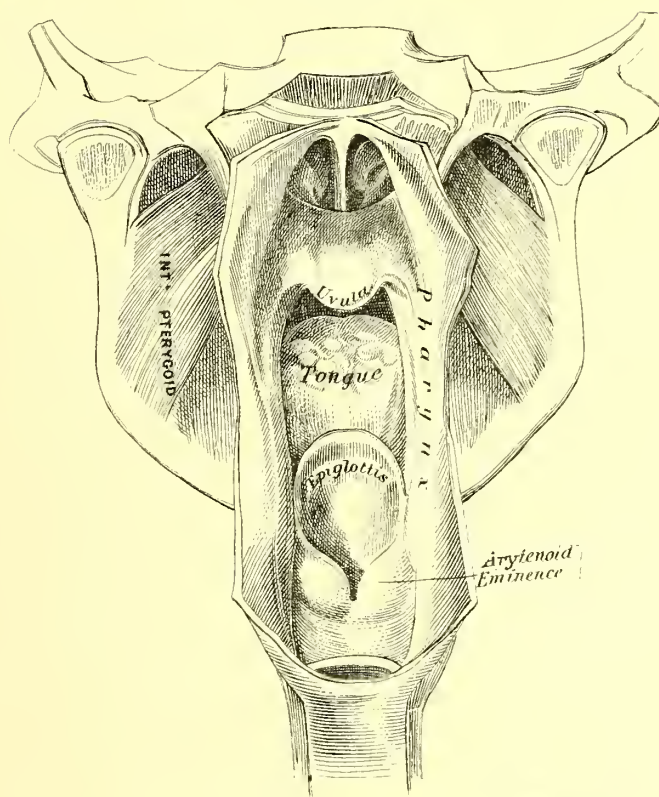


Fig. 6

Variations.—The pharynx, by localized weakness of its constricting muscles, may permit bulging of its walls, especially at its lower part. When such a bulging is pronounced it has received the name of the *pharyngeal pouch*. J. W. Ogle has described a case in which the pouch had attained the size of an egg. Mr. Dendy¹ states that the pouch usually dips down between the œsophagus and the vertebræ. An adventitious valve-like orifice distinguishes its junction with the pharynx. Great irritation may follow the retention of particles of food within it. In one case, as related by Mr. Dendy, the patient was compelled to fill the pouch with soft solid food before ordinary food could pass into the stomach. The contents of the pouch could be subsequently ejected.—The roof of the pharynx is occasionally the seat of congenital hairy outgrowths.²

THE SOFT PALATE.

The Soft Palate (*velum palati*, hanging palate) is a musculo-membranous valve appended to the posterior border of the hard palate. It stretches across the line of junction of the mouth and pharynx, but its posterior free border is projected into the pharynx, of which, indeed, it constitutes a part. Dependent from this border is a mobile, nipple-shaped structure called the *uvula*. At its origin the soft palate is fibrous; but the fibrous structure gradually disappears from before backwards, the posterior two-thirds of the soft palate being entirely muscular. The soft palate presents for examination one border and two surfaces,—an anterior and a posterior.

The border is thin and divided by the uvula into two crescentic portions.

The *anterior surface* is covered with a thick layer of racemose glands, which pour a viscid secretion into the mouth. The presence of these glands gives a yellowish tinge to this surface, and renders it free from folds.

The *posterior surface* is thin, and without glands, presenting a less closely adherent mucous membrane, which is apt to be faintly marked with minute transverse folds.

The soft palate receives the insertion of the Tensor Palati and Levator Palati muscles and gives origin to the Palato-Glossi, Palato-Pharyngei, and Azygos Uvulae muscles. These structures more or less interlace in the substance of the velum.

Mechanism of the Soft Palate.—When at rest, as in expiration, the soft palate is held in its position (obliquely downward and backward) by two pairs of tractors, the Palato-Glossal and the Palato-Pharyngeal

muscles. When elevated, as in inspiration, these muscles retaining their tensile power, the soft palate is acted upon by a pair of superior tractors, the Levato-Palati muscles. When it is raised, as in deglutition, or gagging, the process becomes more complicated. It is now initiated by the last-named muscles raising the muscular portion of the palate to a level with the aponeurotic portion. Succeeding this, the Palato-Pharyngeal muscles contract, elevate the pharynx, and tend to constrict its middle portion. This stage may be divided as follows: first, the elevation of the body of the soft palate, and the apposition of the hinder free end against the posterior wall of the pharynx. Secondly, the approximation of the Palato-Pharyngeal muscles, and the producing of the angle of their convergence toward the middle of the muscular division of the soft palate. Thirdly, the contraction of the uvular muscles. At the completion of the act the oro-pharynx is widened superiorly, while the tonsils, no longer seen in foreshortened profile, tend to be drawn deep within the oro-pharynx. The naso-pharynx is, of course, closed. The motions of the soft palate are indirectly influenced by the Pharyngeal Constrictors and the muscles of the Glosso-Hyoid series, and determine the patency of the Eustachian tubes. Within the range of their influence are the acts of breathing, swallowing, smelling, speaking, and sucking. If it be correct to say that those regions of the body are naturally defined which include muscles of the same related functions, it is seen that in the soft palate we have no unimportant structure, but the centre of a region of the mucous tract toward which converge muscles arising from such remote points as the base of the skull and the thyroid cartilage.

When the soft palate is elevated it can be readily determined by the use of the throat mirror that the naso-pharynx is virtually obliterated. The floor ascends, the lateral walls approximate each other, and the roof, by corrugation, projects the lymphoid structures downward. These actions can be referred to the Superior Constrictor muscle. Cleland¹ believes that the free upper edge of this muscle, by changing from a curved to a straight line, aids the Levator Palati in closing the orifice of the Eustachian tube.

Variations.—The uvula is sometimes congenitally divided in the median line. It is at times greatly elongated by disease, when it may serve as an exciting cause of cough. Hyrtl gives a whimsical account of a man who, having an attack of coughing, involuntarily caught the end of his pre-

¹ Prov. Med. and Surg. Journ., August 9, 1848.

² Journ. of Anat. and Phys., 1881, 244.

¹ Journ. of Anat. and Phys., 1868, 102.

ternaturally enlarged uvula between his teeth and bit it off, thus effecting a cure.—Among the variations of the soft palate may be appropriately included “cleft palate.” For a consideration of this defect, see Teratology.—The structures of the soft palate are frequently asymmetrical, not, however, so frequently from congenital structural causes as from irregular actions of muscles, and from inflammatory invasion.

REMARKS.—The clinical applications of a knowledge of the structure and uses of the soft palate are numerous. The soft palate is liable to syphilitic ulcerations. The ulcerated patches are often seen upon the posterior surface, where they exhibit a tendency to perforate the entire palate-structures. The ulcerated area is always larger posteriorly than anteriorly. The act of elevation of the palate brings the ulcer in contact with the posterior wall of the pharynx, and induces inflammation and ulceration of that portion of the pharynx with resultant stricture or atresia of the naso-pharyngeal orifice.¹

Fibrous tumor of the soft palate is of infrequent occurrence. Mr. Kelbourne King² has described a case observed in a man twenty-eight years of age. The tumor had been growing for three months. It was situated on the left side, and entirely filled the oro-pharyngeal orifice. It projected upward into the naso-pharynx and thence into the nasal chamber. The growth was excised, but the patient died on the sixth day.

Hypertrophy of the glands of the soft palate is a slow process, and a period of from five to fourteen years is usually requisite for the development of a mass sufficient to obstruct the oro-pharynx. The mass may be contained in a separate compartment distinctly limited, spheroidal, and only very slightly connected with the adjacent parts, so that, when its capsule is excised, it may be easily enucleated with the finger.

Carcinoma of the soft palate is always medullary. It may begin somewhat after the same method adopted by the lingual cancer; viz., in first infiltrating the sub-epithelial cells.

In a case, narrated by Birkett,³ a so-called polypus of the parts, in a man aged thirty-four, was excised, when cancerous infiltration ensued, and death followed nine months after the first appearance of the growth.

W. A. Love⁴ has invited attention to the import-

ance of inspecting the anterior surface of the hard and soft palate in the early stages of biliary catarrh. The icteric color appears in these localities earlier than in any other portion of the body.

W. H. Broadbent¹ has described two cases of paralysis of the soft palate in children, accompanied by regurgitation of fluids through the nose in attempts at deglutition. The tone of the voice was nasal and the articulation of sounds imperfect. The soft palate was seen to be pale, flabby, and motionless.

The palato-glossal fold. This fold often spreads out over the tonsil when the latter is engorged, or aids in defining a pocket between itself and the tonsil. A curved probe introduced into this pocket, and made to draw the fold forward, enables the observer to inspect it. It will often be found to contain pellets of tonsillar secretion. In some recognizable states of the tonsil, in which the pellets are too frequently formed, the breath becomes offensive. Under these circumstances the author has with benefit obliterated the fold by excision.

The palato-pharyngeal fold. In inflammatory infiltrations the pharynx often presents swellings along the borders of these folds, which may be mistaken for engorged tonsils.

In facial palsy involving the soft palate, the flaccid structure prevents efficient separation of the naso-pharynx from the oro-pharynx, so that food enters the nose during deglutition.

The *uvula* is convex at its base behind, and has thus a tendency to dispose the mucus descending from the nose to the lateral walls of the pharynx. An excessive flow of mucus is not confined to these normal conduits, but pours over the upper surface of the uvula. The uvula may be elongated, and excite cough by its intrusion within the laryngo-pharynx.

The mechanism of the soft palate has been carefully studied by examination of the living parts. This has been accomplished by inspection from below by the rhinal mirror in the normal subject, and by direct examination in cases of destructive ulceration of the soft palate from above;² also by J. Hilton³ and Schuh,⁴ through abnormal openings in the face, and by the aid of small mirrors inserted through the nasal chambers by Zaufal.⁵

REMARKS.—The space between the pharynx and the vertebræ may be invaded by the products of dis-

¹ For cases with dissection, see W. Turner, Edin. Med. Journal, 1860, lv., 612.

² Lancet, 1871, 264.

³ Trans. Path. Soc. London, 1860, xl., 233.

⁴ Trans. Med. Assoc. Georgia, 1878.

¹ Trans. Clin. Soc. Lond., 1871, 92.

² Cleland, Ibid.

³ Guy's Hosp. Rep., i. 1836, 504.

⁴ Wiener, Med. Wochenschr., 1858, No. 3; see in Med. Times and Gaz., xix. 1859, 357.

⁵ Archiv für Ohrenheilkunde, x. 1875, 133; see, also, a paper by the author in Trans. Col. of Physicians of Phila. 1884.

ease either from the vertebral or the pharyngeal side. The disease known as *post-pharyngeal abscess* or *retro-pharyngeal abscess* is thus located.

The pus in such a collection pushes the posterior wall of the pharynx forward, causing dysphagia. Sometimes it gravitates and forms deep collections of pus in the neck. In a case of this description, carefully reported by Hilton,¹ a large deep swelling occupied the upper part of the left side of the neck as far as the angle of the jaw. The carotid artery was felt pulsating upon the anterior aspect of the swelling, close to the anterior edge of the Sterno-Cleido-Mastoid Muscle. The trachea was pushed forward and to the right side. The collection was opened through the Sterno-Cleido Mastoideus. The patient, a child of twelve months, recovered.

When a pharyngeal abscess is about to burst within, a projection often forms which has been known to press upon and obliterate the aperture of the glottis.²

The tonsil and the adenoid tissue at the roof of the pharynx (pharyngeal tonsil) tend to disappear after the completion of the process of ossification of the skeleton.

The pharynx is furnished with numerous follicular and racemose glands. These are most conspicuous along its posterior wall, where they frequently form enlarged lentil-shaped out growths due to the thickening of the connective tissue about their ducts. Such eminences when numerous form one of the most distinctive signs of follicular pharyngitis.

The naso-pharynx. The adenoid tissue at the roof of the pharynx is sometimes greatly enlarged, and occupies the naso-pharynx, interfering with the action of the soft palate.³

The naso-pharynx is the seat of a peculiar tumor known as fibrous polypus or naso-pharyngeal polypus. It appears to originate at the lateral aspect of the roof, and tends to grow downward and forward into the nose and its connections. It may, however, break down by pressure thin barriers of bone, as the walls of the sphenoidal sinus, the plates of the ethmoid, and other thin facial bones.

Epithelial cancer of the pharynx has been described by Sydney Jones.⁴ A pendulous fatty tumor is described and figured by Holt.⁵

The recess on the lateral wall of the pharynx between the orifice of the Eustachian tube and the posterior wall, is called the fossa of Rosenmüller.

This fossa is used as a guide by the physician in introducing the Eustachian catheter. By first inserting the end of the instrument in this depression it can be felt by gentle traction forward to leave the fossa, glide over the hook-cartilage of the Eustachian tube, and drop into its orifice. The physician is thus reasonably certain of securing the desired object without the necessity of recalling the varying relation of the orifice of the tube to other fixed points of the naso-pharynx.

The pharynx when perforated (as by a fish-bone or projectile) may lead to diffuse suppuration in the neck and to exposure of the basilar process of the occipital bone. Extravasation may take place through this opening in the roof of the pharynx and cause abscesses in various parts of the neck.

A unique case is narrated by Ch. H. Moore¹ of perforation of the pharynx by the superior cornu of the thyroid cartilage, caused by a fall from a horse. Extensive suppuration of the neck followed, and the patient perished at the end of two months. Cases have also occurred in which fragments of straw have perforated the pharynx, causing abscess and extravasation.

Division of the lower part of the pharynx often accompanies lesion of the larynx in suicidal cut-throat. The act of deglutition is necessarily interfered with, the lips of the wound separate at each attempt to swallow, and liquids may even run out of the wound upon the skin of the neck.

THE TONSIL.

The Tonsil (fig. 2, Plate C.) is an almond-shaped body, about nine lines long and six lines wide, lodged in the space between the palato-glossal and palato-pharyngeal folds. This space from the disposition of the folds is narrow above where they converge, and broad below, where they diverge. Hence the tonsil is in contact with the folds above, but is free below. To the outer side of the tonsil lies the Superior Constrictor muscle and beyond this are found the internal carotid artery and the lower portion of the parotid gland. Extending downward in the tonsillar space below the tonsil are scattered a few pea-shaped bodies which resemble the tonsil. These form the infra-tonsillar glands (*cryptæ vestibuli inferiores* of Tour-

¹ Lectures on Rest and Pain.

² Peacock, Trans. Path. Soc., i. 1849, 88.

³ For a detailed account of this condition, see Meyer, Med.-Chir. Trans., 1870, 191.

⁴ Trans. Path. Soc. Lond., 1860, xi. 101.

⁵ Ibid., 1854, 123.

¹ Lancet, 1864, 286.

tual). They are sometimes when engorged the exciting cause of cough by pressure against the base of the tongue.

The tonsil is a glandular structure having a fibrous matrix which affords accommodation for numerous small closed sacs. These are for the most part arranged along the borders of irregular sinuous depressions which open upon the median free surface of the pharynx; the orifices are from fifteen to twenty in number.

REMARKS.—In operations upon the tonsil, such as excision for hypertrophy and incision for abscess, the relation it bears to the internal carotid artery should be remembered. In opening an abscess of the tonsil the bistoury should not be thrust outward. Neglect of this precaution has led to serious complications from bleeding of the wounded structures. The internal carotid artery has thus been opened with fatal results. In cancerous infiltration of the parotid gland, the disease has extended by contiguity to the lateral wall of the pharynx and thence to the tonsil.—The tonsil when engorged may project into the pharynx and tend to obliterate the inter-tonsillar space, the symptoms being for the most part those pertaining to disordered respiration and deglutition. If, however, it enlarges without this median projection, the pressure forward and outward provokes difficulties of mastication, and possibly of hearing. Upward pressure of an engorged tonsil can scarcely fail to push the soft palate upward, and by that means to maintain closure of the orifice of the Eustachian tube when the mouth is closed.—The tonsil may be tightly held by the folds on either side, in which case their division has been recommended.—In the second part of the act of deglutition the tonsil is pulled toward the posterior wall of the pharynx. Sometimes the surface which usually projects medianly is turned directly backward. Under these circumstances interference with the proper accomplishment of deglutition acts as an exciting cause of disease.—The tonsil, even when not enlarged, may be the cause of persistent irritation if

the tonsillar tissue is indurated and lies concealed between closely approximated folds.

Tonsillar abscess usually terminates, if not opened by the knife, by a spontaneous opening into the cavity of the pharynx. Instances are known, however, of rupture of the abscess through the fibres of the Superior Constrictor muscle into the pterygo-maxillary region.¹

It is rational to assume that the overgrowth of the tonsil is an attempt at compensation on the part of an organ engaged in manufacturing blood-corpuscles, when other blood-making structures, such as the medulla of bone, are inactive. The tonsils, if of sufficient size to interfere with oral respiration, should be excised. If, however, they are simply enlarged and do not interfere with respiration, they should be let alone.—The tonsil may become hypertrophied to such a degree as to be felt beneath the skin at the angle of the jaw. In common with other closed gland-structures the tonsil is very rarely the seat of primary malignant growths.

THE ŒSOPHAGUS.

The Œsophagus (gullet) is that portion of the alimentary canal which extends between the pharynx and the stomach. It begins at a point opposite the cricoid cartilage or the fifth cervical vertebra and ends at the cardiac orifice of the stomach opposite the ninth, tenth, or eleventh dorsal vertebra, and measures from nine to eleven inches in length.

The œsophagus is the narrowest portion of the alimentary canal, and in a state of rest is slightly flattened as well as contracted, its mucous membrane being thrown into longitudinal folds so that a transverse section exhibits a stellate oval figure. It is slightly narrowed in passing through the Diaphragm and at the beginning of the thoracic portion. It is, at the latter place, but one inch in diameter. Sappey compares the canal to two elongated cones whose apices join at the last-mentioned constriction.

¹ Reitch, Anatomie Chirurgicale, 416.

EXPLANATION OF PLATE C.

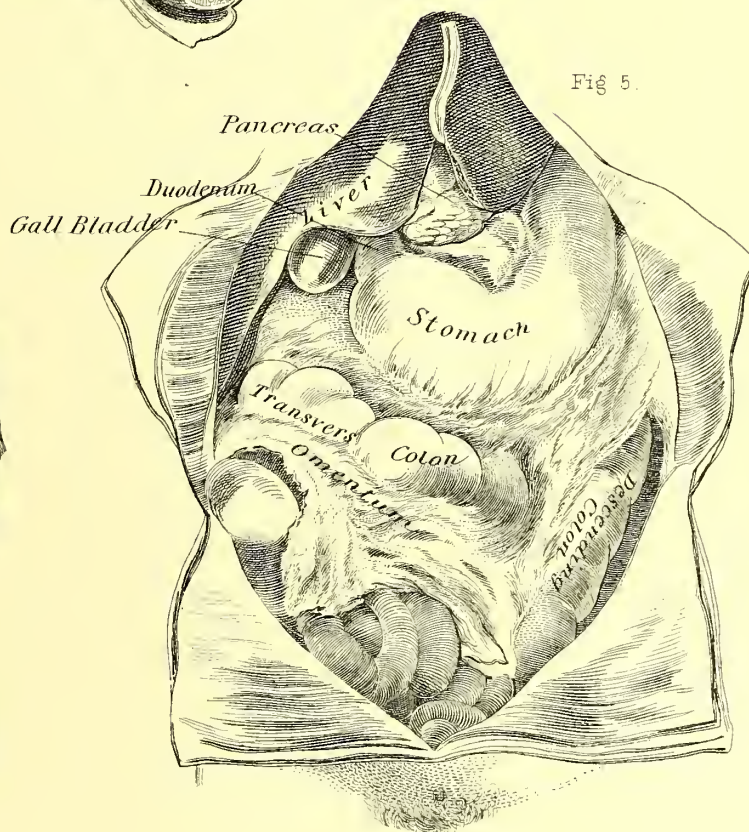
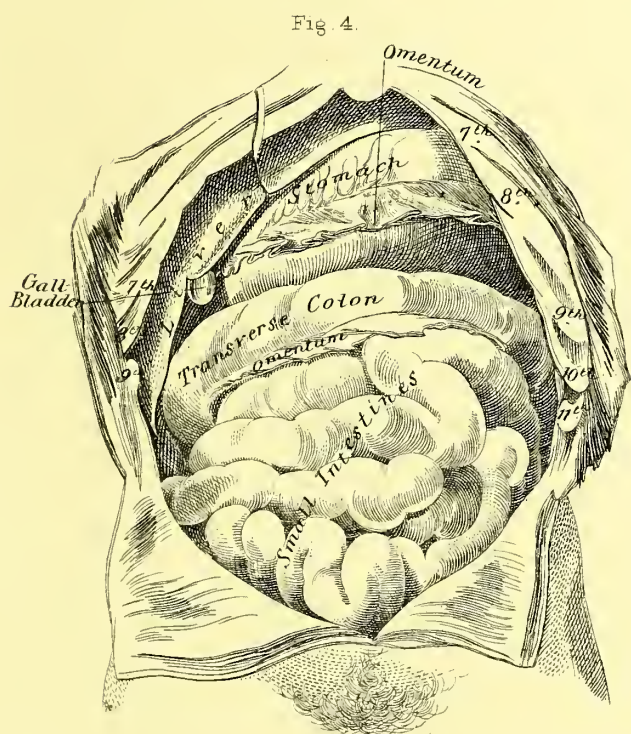
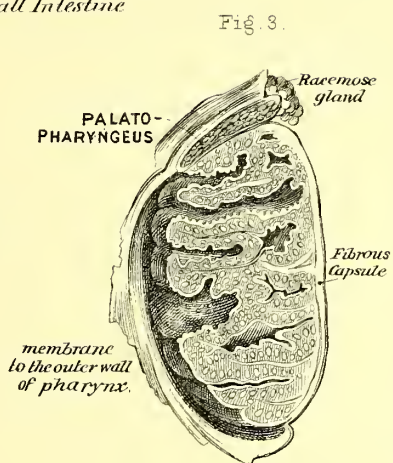
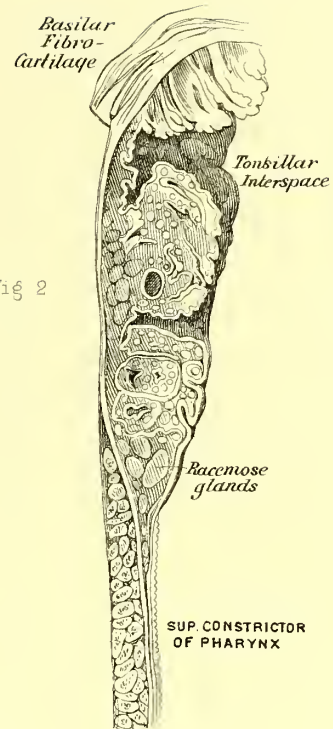
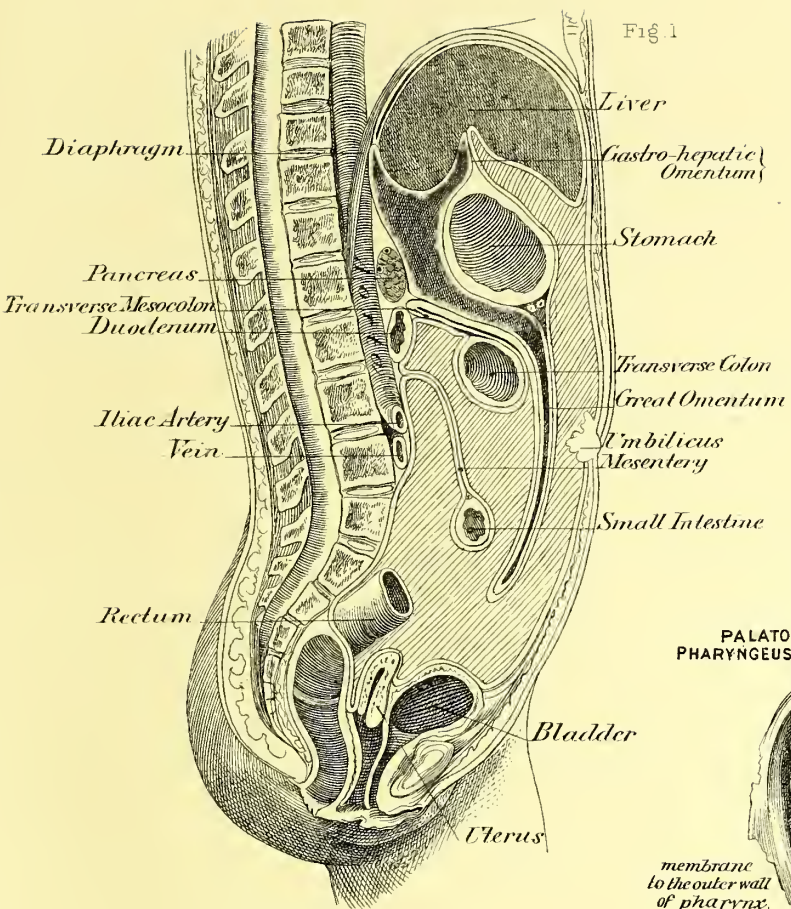
Fig. 1. A diagrammatic representation of the arrangement of the peritoneum.

Fig. 2. The posterior wall and roof of the naso-pharynx, designed to display the adenoid tissue.

Fig. 3. The tonsil.

Fig. 4. The organs of the abdomen *in situ*, in repletion of the stomach; normal.

Fig. 5. The organs of the abdomen *in situ*, in inanition. Drawn from the body of a young woman who died of phthisis pulmonalis.



The œsophagus is composed of a muscular, a submucous, and a mucous coat. The muscular coat presents two layers: an outer (longitudinal) and an inner (circular). The longitudinal layer arises from the posterior median ridge of the cricoid cartilage, and at the sides is continuous with the fibres of the Inferior Constrictor muscle, and is divided into three fasciculi, one in front, and one on either side of the gullet. These unite at the lower part of the canal, and finally are lost upon the walls of the stomach in the longitudinal fibres of that organ. The circular fibres, which are continuous with the lower fibres of the Inferior Constrictor of the pharynx, are slightly thicker than the longitudinal.—At several points on the posterior surface of the canal, the longitudinal fibres are entirely absent.—The muscular portions of the œsophagus in the cervical region are composed of striated muscular fibre; throughout the remainder of its course, of the non-striated variety. In addition to the muscular layers, as above given, Luschka describes several fasciculi which arise from the inferior horn of the thyroid cartilage.

The œsophagus is remarkable for possessing several muscular slips which extend from the canal to different organs. Attention was first directed to these fibres by Hyrtl,¹ who describes a *broncho-œsophageal slip* which arises from the œsophagus and is inserted into the posterior membranous wall of the left bronchus, and a *pleuro-œsophageal slip* which arises from the left wall of the œsophagus and is inserted into the left wall of the mediastinum. Treitz has detected similar fasciculi passing to the pericardium, to the trachea, and to the great vessels.

J. D. Cunningham² has found as the result of fourteen dissections that pleuro-œsophageal muscular filaments were present in thirteen subjects, and pleuro- and broncho-œsophageal muscular fibres in ten. He has noticed muscular fasciculi passing from the anterior surface of the œsophagus to be inserted into the pericardium.

The submucous layer of the œsophagus is abundant, and permits the mucous membrane upon it to be easily raised in folds. The mucous membrane is of a yellow or grayish-red color and is covered with squamous epithelium. At the lower third, racemose glands with well-defined ducts pass through its entire thickness.

RELATIONS AND REMARKS.—The œsophagus describes three curvatures: one, the antero-posterior curvature which answers to the curvature of the vertebral column; and two lateral curvatures. The *first lateral curvature* lies a little to the left of the

median line, and terminates just below the origin of the left bronchus. From this part the *second lateral curvature* extends, which again carries the œsophagus a little to the left of the median line, but brings it at the same time forward so as to terminate at the œsophageal opening of the Diaphragm. The first lateral curvature secures its most important relation with the trachea, which may be said to determine its position; the second retains its most important relation with the aorta; the first might therefore be called the *tracheal curvature*, and the second the *aortic*.

Viewing the relations more exactly, the œsophagus is seen to lie first behind the trachea, then to appear at its left side near the base of the neck. Adjacent to it lie the left carotid artery and the left lobe of the thyroid body, together with the pneumogastric and left recurrent laryngeal nerves. Behind it, separated by loose connective tissue, is the Longus Colli muscle. Within the chest the pleura is in contact with it on either side. It is crossed by the left bronchus as this structure passes obliquely downward and outward at the level of the fourth or the fifth dorsal vertebra, and lies behind the pericardium, where that membrane covers the left auricle. Just as it leaves the region of the left bronchus the œsophagus assumes relations with the aorta in the neighborhood of the fourth costal cartilage. It first lies a little to the right of the aorta, and then, *i.e.*, at about the lower third of its course, it lies in front of the vessel and to the left. It then describes an extended sinuous line about the aorta. To the right and behind it lies the azygos vein. Parallel with it are the pneumogastric nerves; the left nerve passing in front, and the right nerve behind the œsophagus.

Instances are on record of hemorrhage into the œsophagus from the superior vena cava, from the ascending portion of the aorta, and from the innominate or right subclavian arteries. The heart has also been wounded by a foreign body which had lodged first in the œsophagus.

The relations of the tracheal curve are essentially different from those of the aortic curve. In the tracheal, the œsophagus is, relatively speaking, firmly held between the respiratory passages and the vertebral column, and is subject to no considerable deviation from its normal line; but the aortic curve varies in its position with the movements of the thoracic viscera. It is described as lying to the left of the front of the aorta, but it may, if the liver is small and depressed, while the stomach or spleen is enlarged and elevated, lie directly in front or even to the right of the aorta.

¹ Zeitschrift der Wiener Aertze, 1844.

² Journ. Anat. and Phys., 1876, 320.

The aortic curve of the œsophagus must be also regarded as a result of the ascent of the Diaphragm accompanying gastric repletion or similar conditions. Above the point at which the left bronchus crosses the œsophagus, an upper tract may be defined which is liable to invasion by diseased conditions from without, or to obstruction within; while the lower portion is free from any liability to outward pressure or internal occlusion. Out of nine cases examined with the object of determining at what point in the œsophagus foreign bodies may lodge, in seven the author has found that the obstruction existed in the tracheal curve, and in two only in the aortic. In both of the latter, the foreign substances were spicules of bone, and the cases presented unusual features.¹

It may be said that the region of the left bronchus and the region of the cricoid cartilage are favorite places, not only for the lodgment of foreign bodies, but for the initiation of diseased action. Thus, out of forty cases of disease examined, eight only appear to have been located elsewhere. Of the remaining thirty-two, ten were situated at the cricoid, twelve at or near the left bronchus, and ten were found in which the disease, while below the left bronchus, indirectly involved that structure.

The following table may be found convenient:
Length of the œsophagus, ten to eleven inches:—

The distance from the upper border of the cricoid cartilage to the tracheal bifurcation is from four and a half to five inches.

The distance occupied by the left bronchus in crossing the œsophagus is about an inch.

The distance from the left bronchus to the cardiac orifice of the stomach is from four to five inches.

The end of the aortic arch is at about the third dorsal vertebra.

From the incisor teeth to the cardiac end of the stomach, fifteen to sixteen inches.

From the incisor teeth to the left bronchus, from ten to ten and a half inches.

From the incisor teeth to the upper edge of the arch of the aorta, nine inches. To the lower edge of the same, ten to ten and a half inches.

The following conclusions are drawn from the foregoing statements:—

(1) Foreign bodies are liable to be retained at the beginning of the œsophagus behind the cricoid cartilage.

(2) Passing this point, they do not, as a rule, reach the cardiac end, or "lower part," but are apt to be lodged just above the left bronchus as it crosses the œsophagus.

(3) The cricoid region is exceedingly liable to invasion, and if the disease extends thence downward it is often limited by the left bronchus.

(4) It is probable that diseased action may occasionally originate at the point of greatest narrowing of the thoracic portion, viz., just below the superior thoracic aperture.

(5) The region of the left bronchus is very frequently attacked, the disease commencing either behind or just below it, and extending thence downward.

(6) The cardiac end of the œsophagus is less frequently attacked than either the cricoid or bronchial portions.

(7) Resistance at or near the left bronchus can be detected by a probang meeting resistance at eleven inches from the incisor teeth.

(8) The dangers attending the forcible use of the probang below the region of the cricoid become more manifest when the relations of the left bronchus are borne in mind.

Variations.—The œsophagus may unite with the trachea at a point about midway between the lower border of the cricoid cartilage and the point of origin of the bronchi. Answering to some portion of the œsophageal tract as it lies behind the trachea the œsophagus may be reduced to a small tube (atresia œsophagi) and afterward be abruptly dilated to its normal size.—The lower end of the œsophagus may be dilated

¹ See Memoir by author, Phila. Med. Times, 1877.

EXPLANATION OF PLATE CL.

Fig. 1. The muscular layer of the stomach.

Fig. 2. The stomach, seen from without.

Fig. 3. The lower end of the rectum and the margin of the anus. The right third of the figure exhibits the mucous membrane dissected from the submucous connective

tissue, the veins, and the internal sphincter muscle-fibres.

Fig. 4. The structure of the male pelvis displayed by a transverse vertical (frontal) section, and seen from behind.

Fig 1

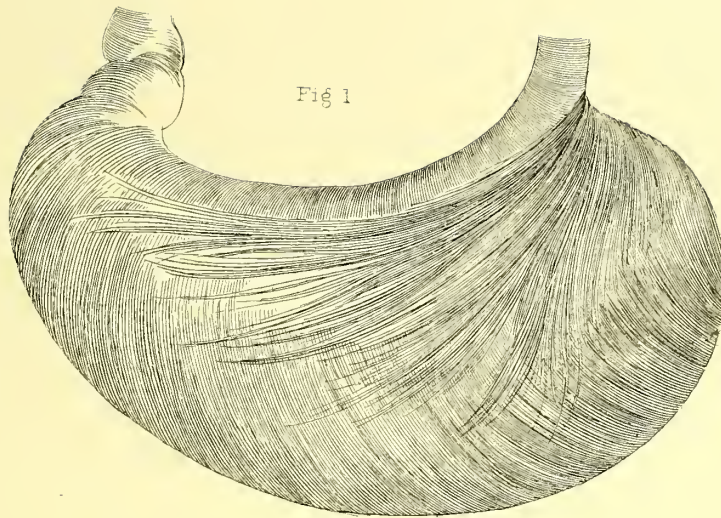


Fig 2

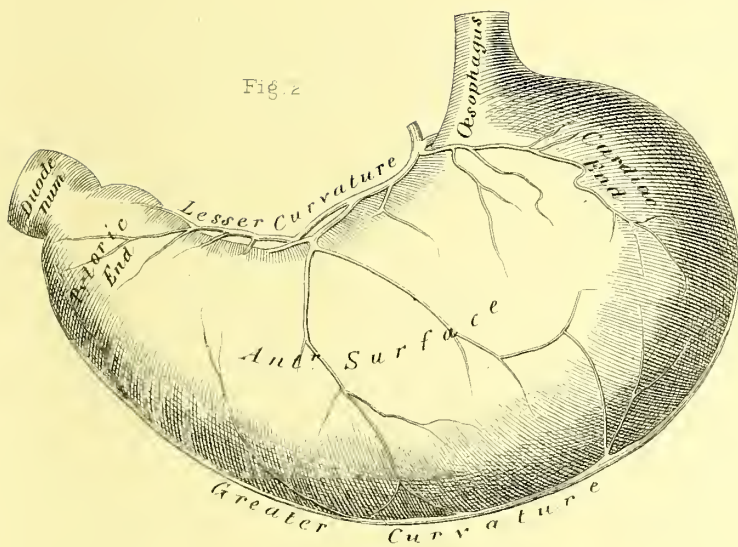


Fig 3

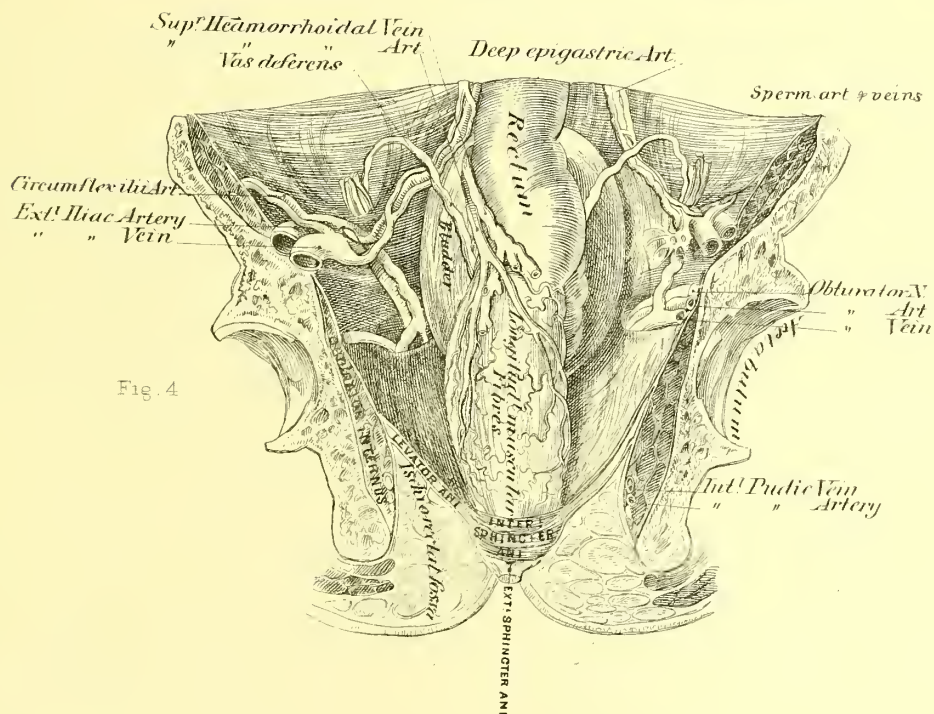
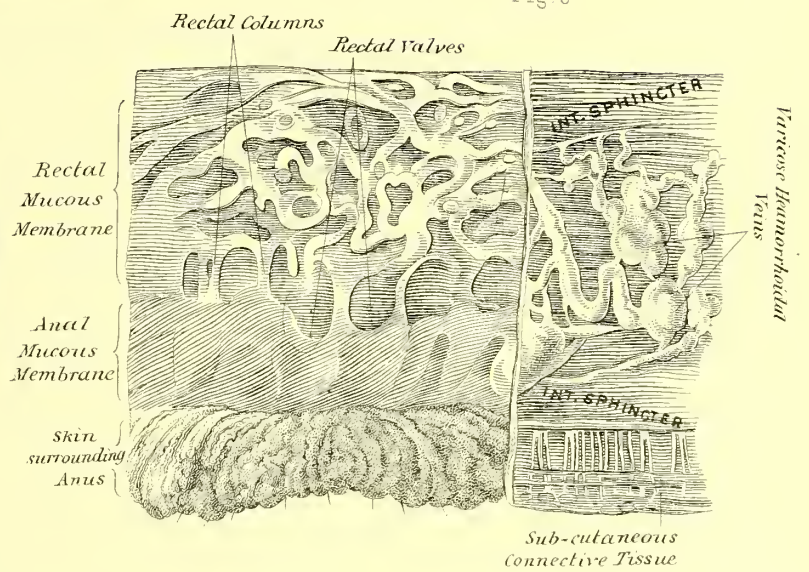


Fig 4

so as to form a chamber antecedent to the stomach—an arrangement which is suggestive of the proventriculus of the bird. Luschka refers to the case of a man who actually ruminated by means of an enlargement of this character.—Of great rarity are examples of duplication of the œsophagus.—The œsophagus and the aorta may pass through the Diaphragm together.

Bloodvessels.—The œsophagus is supplied by the œsophageal branches of the aorta.

The *veins* are tributary to the intercostal veins, and to the hemiazygos and azygos vein.

Bristowe¹ has found hemorrhages from varicose veins lying beneath the mucous membrane to be the exciting cause of death in a case of ulceration of the œsophagus.

Nerves.—The nerves of the œsophagus are derived from the anterior and the posterior œsophageal plexuses of the pneumogastric nerves.

Lymphatics.—The lymphatics pass to glands lodged in the posterior mediastinum.

THE STOMACH.

The Stomach (figs. 1, 2, Plate CI. 4, 5, Plate C.) is that portion of the alimentary canal designed for the reception of food during the first stage of digestion. It is a retort-shaped sac, placed between the œsophagus and the duodenum. It is the most expanded portion of the alimentary canal, and though its size is necessarily subject to great variation, it may be given as follows, viz.: length, 9 to 12 inches; diameter, 4 to 5 inches; greatest circumference, 13 inches; least circumference, 3 inches; vertical measurement at cardiac end, 11 inches; weight, 4 to 4½ ounces; capacity, about 62 fluidounces.

This organ is slightly smaller in the female than in the male. The base, or most expanded portion, is called the *fundus* (cardiac extremity). The narrowed portion for about three inches from its termination in the duodenum is called the *antrum pylori*, and presents a slightly swollen appearance, as its borders somewhat disturb the regularity of the contour of the entire organ. The point of communication with the gullet is the cardiac orifice, which is placed several inches to the right of the fundus. The communication with the duodenum is called the *pylorus* (pyloric orifice). The shortest curvature between these orifices is called the *lesser curvature*; the longest curvature between them is called the *greater curvature*. The two curves as they approach the antrum pylori undergo a change in form, both presenting a

wavy contour as they define the upper and lower wall of the pylorus.

The stomach is situated in the epigastric and left hypochondriac regions, a small portion only of the pyloric extremity projecting into the right hypochondriac region. It is estimated that five-sixths of the stomach lie to the left of the median line and one-sixth lies to the right.

Relations.—Above the stomach are the Diaphragm and the left lobe of the liver; below is the transverse colon. To the right is the spleen; to the left is the liver; in front is the abdominal wall; behind are the pancreas, the portal and superior mesenteric veins, and in part the spleen and great vessels. The cardiac end lies above the left kidney.

The exact relations are of necessity modified by the condition of the stomach, whether full or empty. When *empty*, the organ is nearly perpendicular, the lesser curvature being almost continuous with the gullet, the pylorus depressed, and the two curvatures disposed to the right and left. When the organ is *full*, it rises so as to present its lesser curvature posteriorly and its greater curvature anteriorly. The pyloric end is near the anterior abdominal wall, and is more mobile than the cardiac end, which is fixed by a fold of peritoneum called the gastro-phrenic ligament. For additional relations see Remarks.

According to Sibson, the cardiac orifice of the stomach is situated to the left of the ninth and tenth dorsal spines. A small portion of the fundus lies between the base of the left lung (the Diaphragm alone intervening) and the supra-renal capsule. This exposed portion of the stomach is, however, covered by the lung, when the left base descends so as to be interposed between the surface and the supra-renal capsule.

The attachments of the stomach are as follows:

1. A relatively strong doubling of peritoneum extending from the Diaphragm to the lesser curvature of the stomach called the gastro-phrenic ligament (*supra*).
2. A thin broad fold passing from the pyloric end to the transverse fissure of the liver, called the lesser or gastro-hepatic omentum.
3. A short fold between the cardiac extremity and the spleen,—the gastro-splenic fold.
4. A fold from the greater curvature to the colon,—the gastro-colic fold.

Structure.—The stomach is described as having four coats, named in their order from without inward the serous or peritoneal, the muscular, the submucous or areolar, and the mucous.

¹ Trans. Path. Soc. London, 1857, 175.

The *serous coat* (peritoneal coat) is complete except at the curvatures, where a space exists for the accommodation of the gastric vessels.

The *muscular coat* is composed of three sets of fibres: the external layer, the middle, and the internal. The *external* layer (longitudinal) is the strongest. It presents a general covering to the organ, and is best developed along the lesser curvature. Its fibres are continuous with the longitudinal fibres of the œsophagus. The fibres of the middle layer (circular layer) are arranged in loops like figures of 8 across the short circumference of the organ. They are stoutest at the pyloric end, where they almost entirely inclose and define the pyloric sphincter, being directed toward the pyloric axis. The pyloric orifice, therefore, is an annular ring of muscle-fibres of the middle layer covered with mucous membrane. The fibres of the *middle* of the stomach are continuous with the corresponding fibres of the œsophagus. The *internal* layer (oblique layer), the weakest of the three, is composed of a loop or ribbon-like fold of fibres lodged behind the cardiac orifice. From this locality the fibres radiate, the upper ones being directed toward the lesser, and the lower toward the greater curvature. The upper end of the band is better defined than is the lower. It is thought by late observers that this set of fibres is not continuous with the œsophagus, as was formerly supposed. Retzius¹ states that the muscular fibres of the stomach, particularly those of the oblique set, contribute to form at the lesser curvature a groove opening toward and continuous with the gastric cavity, which serves as a guide for fluids to flow from the œsophagus directly to the pylorus, without mingling with the contents of the stomach. This arrangement is in harmony with that seen in the sacculated and compound stomachs of many animals.

The *submucous coat* is a thin layer of connective tissue intervening between the muscular and mucous coats. It is chiefly interesting from the fact that the loose connection of the mucous with the muscular layer is due to it.

The mucous coat is thicker toward the pylorus than elsewhere, and in the empty organ is marked by longitudinal folds or rugæ, which, however, disappear when the viscus is distended. These folds are most conspicuous toward the pylorus, and along the greater curvature, while they are nearly or entirely absent from the fundus. The mucous membrane lining the pyloric sphincter may receive the name of the

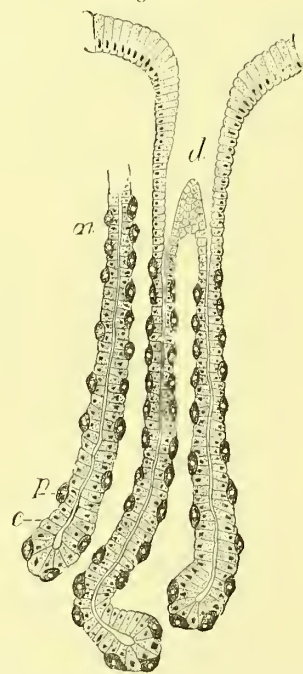
pyloric valve. This membrane is of a pale pinkish or red-brown color; it is thickest toward the pylorus, where small villoid structures are seen. It varies from three-quarters of a line to one line in thickness. Connecting the longitudinal folds are others, placed at right angles, which give the mucous surface a coarsely reticulated appearance. Within the spaces thus formed are seen numerous small pits or alveoli which measure one-hundredth to two-hundredth of an inch in diameter. The alveoli are studded with the orifices of the *peptic glands* (gastric follicles). In addition to these structures the entire surface is marked with minute elevations (mamellæ); these are due to the presence of closed or lenticular glands, and are best seen in the stomachs of infants and children.

The epithelium of the stomach is of the columnar variety. The epithelium of the mucous membrane of the œsophagus terminates at the cardiac orifice abruptly by a well-defined but irregular border.

Extending between the serous and muscular layers are a few longitudinal fibres which may be named the *ligamentum pylori*.

The Glands of the stomach are of the tubular variety, and extend vertically or in slightly tortuous lines through the entire thickness of the mucous

Fig. 174.



The appearance of the peptic glands under a low power; *d*, duct; *n*, neck; *p*, parietal cells; *c*, chief cells.

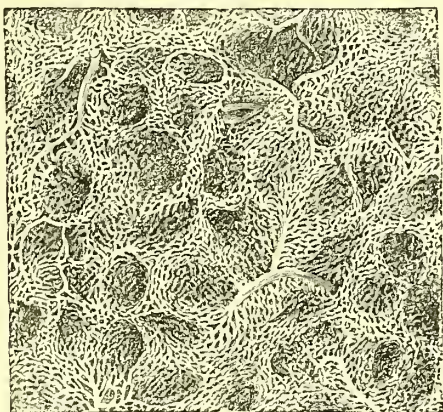
membrane, being smallest where the membrane is thinnest, as at the cardiac extremity; and largest and at the same time more numerous where the

¹ Archiv für Anatomie, 1862, 136.

membrane is thickest, as toward the pylorus. The glands have an average diameter of five-hundredth to three-hundred-and-sixtieth of an inch. The entire number of glands in the stomach is estimated by Sappey to be 4,900,000. Each gland ends either simply, or by one, two, three, or even four divisions. The most complex of these are situated toward the pyloric extremity. The glands may be divided into two groups, which are distinct in details of structure. The first group, called the *muciparous*, or *pyloric* glands, possess wide mouths, and are lined with columnar epithelium similar to that found elsewhere on the gastric mucous membrane. The deep tubular portions of the glands are lined with cubical granular cells. The second group, called the *peptic* or *cardiac* glands, are lined along the duct-like portions with columnar cells, while the fundus and the portion directly above it are furnished with short columnar or polyhedral cells (*c*, Fig. 174, *principal cells*, chief cells, central cells), having free nuclei, and granules. Lying between the principal cells and the basement membrane are a number of larger oval cells (*p*, Fig. 174), which have received the name of the *parietal cells* (superadded cells).

The tubular glands near the pylorus occasionally incline to the racemose type.

Fig. 175.



Appearance of the lining membrane from the cardiac extremity of the stomach, in an injected preparation.

Bloodvessels. Arteries.—The arteries of the stomach are the left and right coronal, the right and left gastro-epiploica dextra and sinistra, and the short gastric arteries.

Veins.—The veins are tributary to the portal vein, the mesenteric vein, and the splenic vein.

Nerves.—The nerves are derived from the anterior gastric plexus from the left pneumogastric nerve; and the posterior gastric plexus from the right pneumo-

gastric nerve. Sympathetic nerves are derived from the coeliac plexus.

Lymphatics.—The lymphatics join the coeliac glands.

Variations.—The stomach is sometimes found temporarily narrowed transversely at a point midway between the cardiac and pyloric ends by over-action of the circular muscular fibres at the point of constriction. Albers¹ figures an example of a permanent constriction of the stomach which served to divide the viscus into two chambers or sacculations. This arrangement permits comparison to be made between it and the condition normally present in the kangaroo.

REMARKS.—The stomach in the foetus is nearly vertical by reason of the two nearest fixed points of the alimentary canal, viz., the oesophagus at the Diaphragm, and the terminal portion of the duodenum, being in a line but slightly deflected from the perpendicular. Coincident with the dilatation of the lower side of the organ, it becomes more obliquely placed, and the narrowed or pyloric end is carried to the right.

These changes may be advantageously borne in mind in comparing the empty with a full stomach (figs. 4 and 5, Plate C.). In *fasting*, the pyloric end of the stomach falls, and the entire organ is placed very obliquely if not nearly vertically in the abdomen. In a word, it tends to return to the foetal or unused position. The fundus lies high up in the left hypochondriac region. The curvatures of the organ are scarcely apparent. The pylorus does not touch the liver, but lies near or upon the vertebral column at the level of the eleventh dorsal vertebra (Braune). The transverse colon lies across the organ, or may even be above it, when it will lie in contact with the Diaphragm (Hyrtl). In this event some coils of small intestine are apt to be associated with it. Hence the distressing flatus of some forms of anorexia, and the pain which is referred to the "side," i. e., left hypochondriac region, by anæmic females.

The prolapse of the pyloric end in the adult when the stomach is empty is due to two causes: first, the increased weight of this portion of the viscus; second, the suspension of the organ by the oesophagus at the cardiac end. When the stomach is habitually collapsed, the pylorus always lies below the plane of its normal position, and differs but slightly in appearance from the first portion of the duodenum, and may, as in a case reported by J. W. Trotter,² extend to a point one inch below the anterior superior

¹ Atlas der Path. Anat., iv., Taft I. fig. 1.

² Trans. Path. Soc. Lond., iii. 318.

spinous process of the ilium. Hence the facility with which in such subjects duodenal regurgitation may occur. It is unnecessary to resort to the supposition of tight-lacing, as has been done by some writers, to account for the prolapsus of the pylorus in anæmic persons.

One of the most important *indirect relations of the pyloric extremity* is entered into by the head of the pancreas. When enlarged by cancer this portion of the gland may press against the pylorus and almost obliterate it.¹ Cancerous infiltration of the pylorus, by increasing its weight, may draw this portion of the stomach further down in the abdomen than is normal, viz., as far as the eleventh dorsal vertebra, opposite the umbilicus, or as above stated to a point near the ilium. It is apt, moreover, to become superficial, by reason of the inflated condition of the first portion of the duodenum, whose relations are necessarily disturbed by the descent. As a result a tumor answering to the cancerous mass may often be felt through the abdominal walls.

In *repletion*, the stomach, besides becoming transverse to the vertical axis of the trunk, advances in front by increased dilatation of the lower side of the organ. The fundus occupies almost entirely the left hypochondriac region. An instrument penetrating the sixth, seventh, eighth, or the ninth left intercostal space would enter it. The pylorus is raised and deflected to the right—lying about two inches and three-quarters from the median line. The curvatures of the entire organ are pronounced, and the greater one advanced forward. The transverse colon lies below the stomach, while the pancreas lies directly behind it, and, in the opinion of Hyrtl, is compressed by it, so that an outflow of pancreatic secretion is assured. At the same time it would appear that the vessels accompanying the pancreas are free from pressure since they lie along the upper border of the organ. The common bile duct and portal vein are also free from pressure.

When a tumor, which has been detected in the position above indicated, can no longer be outlined, and its site is occupied by a tympanitic surface, it is probable that the transverse colon has descended from its usual high position, and is lying directly in front of the indurated mass.

The stomach may assume *proportions* greatly in *excess* of those stated above as normal. The superior curvature has been known to measure $37\frac{1}{4}$ inches.

In the operation of gastrotomy the organ will be

found distended to an enormous extent—if the obstruction lies below the pylorus—but contracted and in the position of fasting if the obstruction is oesophageal.

In extreme degrees of distension the stomach presses upward against the Diaphragm, and laterally against the lower ribs. It thus interferes with a free respiratory movement, and disturbs the action of the heart. Hence the palpitation in prolonged or excessive gastric repletion, and the reference of the sensations of dyspepsia to the region of the heart.

The *effects of respiration* upon the stomach are briefly as follows: The pylorus is lowered by a forced inspiration to the level of the umbilicus. The cardiac orifice is drawn downward by the crura of the Diaphragm for about one inch.

An application may here be made of the *law of localization of diseased action*, viz., that parts enjoying the most rest are least liable to involvement by structural disease. Out of 220 instances of gastric ulcer collected by W. Brinton, but 4 were found in the cardiac pouch, while 32 were found in the pyloric end. It is not so easy to explain the occurrence of 86 ulcers on the posterior surface, and 56 on the lesser curvature, while 10 only were met with on the anterior surface, and 5 on the greater curvature. It is probable, in view of these striking contrasts, that the lesser curvature and posterior surface have much in common, and that they are in a condition of greater functional activity during digestion, or are subjected to greater strain by the change from the empty to the distended position.

During the gradual *process of restitution* which is effected after every meal, the muscular coats of the stomach contract. Should this contraction be irregular, a constriction will often take place about midway between the extremities; this, when persisting after death, has received the name of the hour-glass constriction. (See Variations.) When the contraction is very marked, it is associated with a twisting of the entire organ. In a case of this kind, which was carefully studied by L. Mazzotti,¹ the stomach was found occupying nearly the whole of the umbilical region. The organ was so constricted that the upper left portion was distended with gas and nearly vertical, while the horizontal right portion was collapsed and described almost an entire circle, the contracted part being the centre about which the rotation was effected. The organ being removed and distended the normal appearance was at once restored. A similar twisting

¹ Sewall, Med. and Phys. Journ., xxxi. 96.

¹ L'Union Médicale, 1875.

of the pyloric portion has been observed in cancer of the pylorus.

In diaphragmatic hernia the stomach and a portion of the transverse colon may be found lodged in the left side of the thorax.

The conspicuous relation existing between the greater curvature of the stomach and the omental cavities occasionally enters into a study of the morbid anatomy of the organ. Thus Brinton records a case of perforating ulcer of the stomach which opened into the cavity of the lesser omentum. Ponfick¹ describes in detail an aneurism the size of an almond situated on the right gastro-epiploic artery, which, bursting, escaped into the peritoneum, and the blood passed into the tissues along the base of the great omentum.

Perforating ulcer of the stomach and cancer of the stomach may communicate with the colon.—According to Pavy, ulceration of the stomach may prove fatal by opening into a branch of the splenic artery.²

THE SMALL INTESTINE.

The Small Intestine (fig. 4, Plate C.; Plate LXIX.) is that portion of the alimentary canal between the stomach and the colon. It measures from twenty to twenty-five feet in length, and constitutes about two-thirds of the length of the digestive apparatus. This enormous bulk of tissue is entwined in coils held together by the mesentery, and occupies the umbilical region, although portions may be found in any of the regions of the abdomen.

The small intestine is larger above than below, a fact which has led some authorities to speak of it as funnel-shaped; the difference in the diameters scarcely warrants this comparison, however, though it is known that the measurements slightly diminish as the lower portion of the ileum is reached. The canal is divided into three portions, the duodenum, the jejunum, and the ileum.

THE DUODENUM.—The Duodenum (fig. 4, Plate CII.) is the smallest of these divisions, and is without mesenteric attachment. It extends from the pylorus at the right of the first lumbar to the left side of the third lumbar vertebra, and is fixed at its transverse portion by the superior mesenteric artery and by the pancreas. It is somewhat horse-shoe shaped, with its concavity directed to the left, and measures twelve inches in length. It is divided for purposes of de-

scription into three portions, the *ascending* (upper border of horseshoe), the *descending* (the curve of the horseshoe), and the *transverse* (the lower border of the horseshoe).

The *ascending*, or the shortest portion, starts from the pylorus of the stomach, and is directed upward, slightly backward to the right, where it lies in contact with the neck of the gall-bladder and the under surface of the liver. In front are the gastro-colic omentum and the abdominal parietes. Behind are the hepatic vessels and the gastro-hepatic omentum. The ascending portion ends abruptly in the *descending* portion which lies either upon or along the inner border of the kidney. It is embraced by the pancreas at its median anterior and posterior borders. The hepatic flexure of the colon is in front, while behind are situated the inferior vena cava and the common biliary duct.

The *terminal portion* is slightly the longest while the narrowest of the three. It passes across to the left side of the third lumbar vertebra to terminate at an angle in the jejunum. It is lodged deeply in the substance of the transverse mesocolon. Behind are the inferior vena cava, the thoracic duct, the aorta, the vertebral column, and the crura of the Diaphragm. Above lies the pancreas; in front, the stomach, from which it is separated by the peritoneum of the sac of the greater omentum.

The peritoneum forms a covering of the duodenum in the same manner as in the other divisions of the small intestine, except in its descending portion where the posterior surface is within the retro-peritoneal space.

THE JEJUNUM AND THE ILEUM.—The Jejunum and the Ileum may be considered together. They form a continuous tract measuring from fifteen to twenty feet in length, united posteriorly to the vertebral column by a long mesentery. The division is arbitrary. By general consent the first two-fifths have received the name of *jejunum*, and the remaining three-fifths the name of *ileum*. The walls of the former are somewhat thicker than those of the latter. The jejunum begins slightly to the left of the median line at the second lumbar vertebra; and the ileum terminates at the ileo-cæcal valve in the right iliac region. The general direction of the intestine is from left to right, and the mesentery of necessity pursues a similar direction, becoming broader as it descends from the second lumbar vertebra to the right sacro-iliac junction. When the jejunum and the ileum are empty they sag and in the main lie in the hypogastric region. In the emaciated subject they may be dragged down

¹ Virchow's Archiv, lxxvii., 1876, 384 (fig.).

² Med. Times and Gaz., 1866, 35.

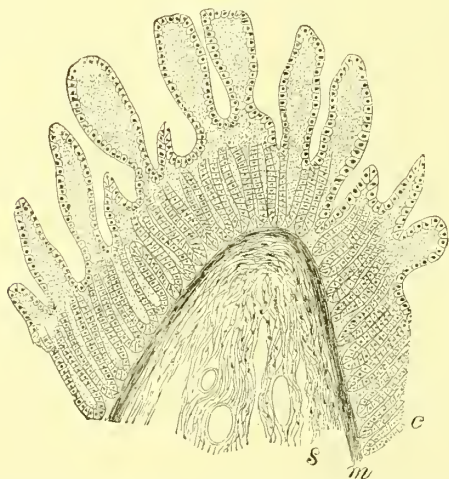
in great part into the pelvis. The coils of the intestine generally occupy the umbilical region, extending somewhat beyond it on either side, where they are ordinarily covered by the greater omentum.

The coats of the small intestine are four in number, the peritoneal, the longitudinal and circular muscular coats, the submucous coat, and the mucous membrane.

The *peritoneal* covering entirely incloses the canal save where it is joined by the mesentery. The *muscular coat* is better developed in the upper than in the lower part where the fibres are thinner and paler. The *longitudinal fibres*, weaker than the circular, lie immediately beneath the peritoneum, to which they are rather intimately attached. Though but moderately developed at any point, they are best seen on the anterior portion of the bowel. Below, this layer is continued over the ileo-cæcal valve upon the colon. The *circular layer* is composed of continuous fibres arranged about the entire circumference of the canal in a somewhat spiral manner. Unlike the longitudinal fibres they are involved in the formation of the ileo-cæcal valve. The *submucous layer* is better developed in the small intestine than in either the gastric or colic walls. It contains a few weak muscular fibres.

The *mucous coat* is probably the most complex structure of the kind in the body. Its essential features are as follows: To a mucous membrane presenting the general characters of all such surfaces are added (1), a series of remarkable folds; (2), a highly developed glandular system; (3), and an elaborate set of radicles of the lymphatic and portal systems projected into the interior of the bowel and constituting the *villi*.

Fig. 176.



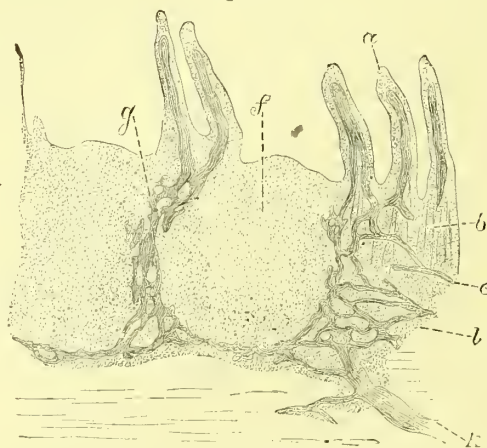
From a vertical section through a fold of the mucous membrane of the jejunum of a dog. *c*, the mucosa, containing the crypts of Lieberkühn, and projecting as the villi; *m*, muscularis mucosæ; *s*, submucosa.

(1.) The *folds* are termed the *valvulae conniventes*, or the valves of Kerkring. They are most numerous in the duodenum, and are continued as conspicuous features until the lower part of the ileum is reached, when they gradually disappear. They are composed entirely of duplications of the mucous membrane. They vary in shape from a crescentic fold to one possessing abrupt ends. Occasionally a fold extends entirely round the bowel, while others—and these are the more numerous—describe a smaller curve. They are about two-and-a-half inches long by one-third wide, but are somewhat larger in the duodenum where they overlap one on another. Not infrequently a fold divides again to unite after a short distance, inclosing an island-shaped space between. The folds present a peculiar arrangement as they reach a Peyerian patch. Here they are either arrested or pass partially over it in faint lines.

(2.) The *glands* are of three kinds: racemose, tubular, and closed.

The racemose glands are confined to the upper portion of the bowel; namely, to the duodenum and the beginning of the jejunum. In the duodenum, extending from just below the pylorus to near the descending portion, numbers of *duodenal glands* are seen which have received the name of glands of Brunner.

Fig. 177.



From a section through a part of a human Peyer's patch, showing the distribution of the lymphatic vessels in the mucosa and submucosa. *a*, villi, with central chyle vessel; *b*, Lieberkühn's crypts; *c*, region of muscularis mucosæ; *f*, lymph follicle; *g*, network of lymphatics around the lymph follicle; *l*, lymphatic network of the submucosa; *k*, an efferent lymphatic trunk.

The *tubular glands* are exceedingly abundant, being found everywhere throughout the small intestine.

The *closed glands* are rounded bodies lodged in the submucous coat, a small portion only appearing upon the free surface. They are very vascular, and have solid contents. They are appendages of the lymphatic system.

When a closed gland is isolated it is called *solitary*; when a number are collected in a small space they are called *agminated*, and the group itself is commonly spoken of as a *patch of Peyer* or *Peyerian patch*. The last-named group is found only upon the anterior surface of the ileum opposite the attachment of the mesentery.

(3.) The *villi* are distributed everywhere throughout the canal. As exceedingly minute processes they arise from the surface between the glands, commonly of a conical or clavate form, while in the duodenum they are somewhat lamelliform. They measure from one-fourth to one-third of a line in length. Each villus possesses a delicate lymphatic vessel, an artery, a vein and a nerve, as well as a delicate fasciculus of muscular fibres.

The *epithelium* of the small intestine is columnar.

Variations.—Billard¹ reports a case of a male child that died three days after birth, in which it was found that the lower third of the duodenum ended in a cul-de-sac, with fluid contents. The small intestine beyond the occlusion was so small that it barely admitted a female catheter. Förster² describes a somewhat similar specimen involving the jejunum.—For accounts of diverticuli of the small intestine, see p. 395.

REMARKS AND RELATIONS.—The Duodenum enters important relations with the stomach, liver, pancreas, transverse colon, jejunum, kidneys, supra-renal capsules, superior mesenteric artery, inferior vena cava, and aorta. Most of these relations are invariable, although those which pertain to the first portion of the duodenum are subject to greater changes than the others. It has been noticed, in describing the variations in the position of the pyloric extremity of the stomach, that under some conditions it appeared to glide almost insensibly into the first portion of the duodenum. In this condition both structures are empty and deep-seated, and easy regurgitation of ingesta and bile may occur from the duodenum into the stomach, while gall-stones may be lodged in the latter organ.³

When the stomach and duodenum are moderately distended, the first portion of the latter lies obliquely in front. It is near to, if not in direct contact with, the liver or gall-bladder. It is in this position that adhesions occur in so large a proportion of the cases of gall-stone migration, with subsequent escape of the calculus into the duodenum.—It is the right wall of

this portion which is frequently selected for ulceration. Krause found that out of sixteen instances twelve were situated in the upper portion.

The vertical or middle portion of the duodenum lies between the vertebral column, the kidney, and the colon. It holds a fixed position with respect to the pancreas and pancreatic duct. When the ascending colon is distended, the vertical portion is thrown from the right to the left of the median line, moving altogether about two inches. It may lie directly to the right side of the first lumbar vertebra, or upon the twelfth dorsal vertebra, to the inner side of the inferior vena cava.

The relations between the first and the second portions of the duodenum and the termination of the ascending and beginning of the transverse colon are held by W. H. Flower¹ to have a significance referable to the primordial relations of the parts.

It is evident that the duodenum may communicate with the colon by a fistulous orifice either at the first or second of its divisions.

Sanderson² has recorded a case of the kind which occurred in a male, aged 30 years. Death ensued after an illness of two weeks. At the autopsy it was found that, at a distance of nine lines from the pylorus, the duodenum communicated by a wide aperture with a pouch about as large as a turkey's egg. By its posterior wall the pouch was very firmly adherent to the head of the pancreas, in front of which it lay. Below, the wall was inseparably blended with that of the transverse colon into which it opened by a valvular aperture large enough to allow of the passage of a swan's quill.

The lower portion of the duodenum is more fixed than any other portion of the intestine. This is chiefly owing to the relation entertained by it with the superior mesenteric artery, which passes over and in front of the duodenum. It is, moreover, fixed by the root of the mesocolon in front and by the pancreas above. In that rare diseased condition, aneurism of the superior mesenteric artery, the sac has been known to burst into the duodenum twenty-two months before death, thereby causing repeated attacks of hæmatemesis.³ In two other cases, reported by J. A. Wilson,⁴ pressure of the aneurismal sac had interfered with the flow of bile and induced jaundice.

The duodenum has been known to be ruptured by

¹ *Traité des Malad. des Enfant. nouv.-nées*, Paris, 1828, 348, fig.

² *Missbildungen*, Taf. xxiv. fig. 24.

³ *Jeaffreson*, *Br. Med. Journ.*, May 30, 1868.

¹ *Med. Times and Gaz.*, March, 1872, 291.

² *Tr. Path. Soc. Lond.*, 1865, xiv. 173.

³ *Gairdner*, *Clin. Med.*, 1862, 504.

⁴ *Medico-Chir. Trans.*, xxiv. 221.

violence, notwithstanding its sheltered position. Direct blows can scarcely reach the duodenum. The liver and transverse mesocolon protect its first portion as well probably as the transverse colon protects its transverse or terminal portion. Poland¹ cites three cases of rupture, in one of which there was a simple rent, one inch long, situated on the convex border of the first portion. In the second case the rent was likewise small, but situated on the descending portion; while in the third the gut was torn entirely across. Eccles² describes a case in which a child of twelve months suffered severance of the transverse from the vertical portion through a fall.

In cancer of the pancreas, the duodenum may become greatly contracted. The gut, according to Sir A. Cooper, may be forced forward by an engorged and distended thoracic duct.

The duodenum is often seen in emaciated subjects lying *above* the level of the transverse colon.

The regions of the abdomen normally occupied by the jejunum and ileum are the epigastric, umbilical, and portions of the other regions. The exact position varies exceedingly according to the condition of the stomach and of the colon. Thus, when the stomach is full, the intestines are depressed; when it is empty, they are elevated, and are often in contact with the Diaphragm in the left hypochondriac region. In distended states of the colon the intestines are excluded in great part from the lumbar, hypochondriac, and epigastric regions. When, in an obscure condition of the abdominal organs, it is desired to show from which portion of the cavity a tumor has projected, it is useful to remember that the tumor displaces the intestine in front of its line of advance. Thus, in enlarged conditions of the bladder, ovary, and uterus, the intestines are carried upward; in enlarged spleen downward and to the right. In peritoneal effusion they lie at the umbilicus in the recumbent, and in the epigastric region in the erect position. The last-mentioned fact is of value in distinguishing abdominal tumor from ascites.

"The small intestines when distended and occupying the pelvis have been known to so press upon the rectum as to prevent the lodgment of injections, and to cause the doubling of the long tube, which has led to the supposition that the obstruction was at the extremity of the colon, instead of in the ileum as appeared after death."³

In a state of health the coils of intestine are closely applied to one another, so that it is possible for a portion of a coil to be opened and yet no feculent matter escape into the peritoneal cavity. It also follows that direct lesions of the mesentery are rare, and that the mesenteric side of the bowel is protected. However, a case is recorded by Birkett in which a rent one-and-a-half inch long, beginning in the mesentery, extended into the bowel. Bright¹ mentions a case in which convolutions of the small intestine, as well as the colon and omentum, lay in front of the liver and pressed it back.

The existence of fibrous adhesions uniting any portions of the coils of the intestine may seriously interfere with the ranges of variation in the relations of the bowel to the neighboring organs.

The anatomical considerations pertaining to intestinal obstruction naturally are of two kinds, viz., intrinsic and extrinsic. The intrinsic include *intussusception* and *torsion*. The extrinsic relate to peritoneal adhesions, or to *incarceration* of a portion of the intestine either within or without the abdomen.

Intussusception is caused by irregular contraction of the circular muscular coat of the intestine. The portion so constricted having a diameter much less than that directly beneath it, is urged by the general downward peristalsis of the bowel to enter the lower portion. It is thought by W. Brinton, who has made an exhaustive study of the subject,² that intussusception at this stage, as seen in the dead bodies of "young and well-nourished subjects, may occur in the irregular contractions of the last agony of death or be due to the rigor mortis of the dead intestine." There is no objection to the acceptance of the view that intussusception without obstruction may often take place during life, the symptoms attending such an occurrence being simply those of severe colic. When, however, the condition is maintained sufficiently long to be complicated with inflammatory effusion, obstruction rapidly supervenes. At the site of the invagination there are three thicknesses of the bowel. First, and most internal, is the constricted portion, which induces the invagination; second, the vagina-like portion embracing the above; and thirdly, the slightly dilated bowel below the intussuscepted point. The inflammatory effusion taking place between the serous surfaces of the first and second coverings will in a short time obliterate the narrow canal between them.

The arrangement of the mesentery determines

¹ Guy's Hosp. Rep., 1858, iv. 123.

² Med. Times and Gaz., 1863, 497.

³ Diseases of the Rectum. T. B. Curling, 4th ed., 177.

¹ Guy's Hosp. Rep., 1840, 317.

² Intestinal Obstruction.

from the very first a peculiarity of shape which all the succeeding phenomena tend to increase. The inverted middle layer or thickness receives, not merely the inner thickness but a kind of conical wedge of the mesentery common to both. The compression thus exercised on the large and numerous mesenteric vessels soon brings about a complete stagnation of their contents, followed by ecchymosis, or even by copious hemorrhage, in the adjacent uninjured mesentery, as well as by congestion and swelling of all the layers of the invaginated parts, and hemorrhage from the mucous membrane forming its innermost surface. Brinton¹ thus describes the appearance of this displacement: "The axis of the invaginated part diverges from that of the bowel containing it until, as the inversion proceeds, it forms a segment of a much smaller circle, and points by the terminal orifice of this segment to the mesenteric edge of the outer layer, with which the lowest part of the inversion is often in contact. The more distensible external or convex part of the middle layer is for the same reason thrown into folds somewhat resembling *valvulae conniventes*."

The process is modified by the presence of the ileo-cæcal valve. A constriction just above the valve will, by its pressure downward, carry the valve, vermiform appendix, and cæcum downward within the colon. As a very rare occurrence the ileum passes into the cæcum through the ileo-cæcal valve.²

As a result of obstruction of the large intestine fecal matter may be forced up through the ileo-cæcal valve. In order that this should be possible, extreme distension of both cæcum and ileum becomes necessary, for in this way the efficiency of the valve is destroyed.

Torsion of the small intestine is due to the irregular action of both the longitudinal and the circular fibres. It is occasionally met with as a complication in hernia. M. W. Taylor³ has recorded a rare instance of a torsion in the form of a knot on the lower part of the ileum occurring in a married woman forty years of age.

Extrinsic causes of obstruction are frequently found in adventitious bands of fibrous tissue extending between the loops of small intestine or from them to adjacent organs. J. H. Aldridge⁴ has recorded a case in which the ileum above the ileo-cæcal valve had become firmly adherent to the posterior wall of the uterus.

Obstruction by incarceration is rarely of a character differing from inguinal or femoral hernia (q. v.), although it is necessary to bear in mind the possibility of an incarceration due to causes of another character. Of this condition a few examples will be given. A loop of small intestine may be caught, according to Delafield,¹ in the foramen of Winslow. Two feet of small intestine have been known to pass up into the left pleural cavity behind the *ligamentum arcuatum externum* in a child ten days old.² The escape of a knuckle of intestine through a hole in the omentum has occurred.

Again, diverticuli of intestine may act as factors in confining the bowel.

The existence of diverticuli in the form of long finger-like projections from the small intestine has long been known. They join the convex surface of the ileum about three feet above the ileo-cæcal valve, and vary in size from a small tit-like projection adherent to the mesentery to a process over three inches long. The walls possess abundant muscular tissue, and are furnished with villi. They have been known to become ulcerated. Their origin is believed to be due to the retention of the duct of communication between the vitelline sac and the intestine. In some cases diverticuli retain their primal relations to the umbilicus either by the full diameter, or by a fibrous cord. Hyrtl³ found one with five branches in a hemicephalic monster. T. W. King⁴ found a diverticulum united to the umbilicus in a child a year old.

Jas. H. Thompson⁵ describes a case of a male aged twenty-five years in whom a coil of jejunum escaped through a space formed by adhesions between the end of a diverticulum and the mesentery, where it became strangulated. Parise⁶ describes a similar case in which abdominal section was performed.

Rupture of the jejunum occurs so frequently at the upper portion of this bowel as to lead Poland⁷ to the conclusion that the fixation of the transverse portion of the duodenum causes the strain of the contusion to be most severely felt at or near the end of the last-named viscus. Thus, out of nine cases collected by him, in which the exact locality of the rupture was stated, seven occurred near the duodenum, one at the junction of the middle and upper

¹ Pathological Anatomy.

² Boston Med. and Surg. Journ., 1838, 114.

³ Typog. Anat., 684.

⁴ Guy's Hosp. Rep., i., N. S., 1842, 470 (Figs.).

⁵ N. Y. Med. Journ., xiv. 55.

⁶ New York Med. Journ., xviii. 113.

⁷ Poland, A., Guy's Hosp. Rep., 1858, series iii., iv. 123.

¹ Loc. cit., p. 44, figs.

² Ibid., 51.

³ Edin. Med. Journ., Aug. 1871, 126 (fig.).

⁴ Lancet, 1860, ii. 262.

thirds of the jejunum, and one only in the lower part of the jejunum. In an example of this rupture reported by Mason,¹ occurring in a man aged twenty, who slipped and fell on the pavement, a small lacerated wound was found in the upper part of the jejunum, while in the last portion of the duodenum a clot of blood the size of a walnut was seen under the mucous membrane.

In intestinal hernia the patient may (from the knuckle acting as a fixed point) suffer rupture of the intestine from blows or falls. The rupture may occur at any point between the duodenal and hernial attachments. Poland cites three examples in which rupture of the intestine was coincident with hernia, and in all of these it was suspected that the hernial incarceration was a factor in the production of the lesion. The cases are almost necessarily fatal, and in the not unlikely event of herniotomy having been performed with the hope of relieving the condition, the real cause of mischief being obscured, medico-legal questions of great interest are apt to arise. Thus "a woman, affected with femoral hernia which occupied the labium, was struck by her husband on the abdomen, and died in twelve hours. The husband was convicted of having caused her death. The defence set up was, first, that the rupture occurred in the hernial sac, and that the rent in the bowel was caused by the efforts of the surgeon in reducing the hernia; and, secondly, supposing this not to have been the case, that the rupture was spontaneous and accidental from yielding of the diseased bowel. The arguments against these were, first, the pain came on immediately after the blow, second, the ruptured bowel was at a considerable distance from the sac, third, no inflammation or fecal matter was found in the sac, fourth, distinct external marks opposite to where the ruptured intestine lay, fifth, no appearance of ulceration of the mucous membrane."

In very severe contusions from blows received in front, it is possible, especially in thin persons, to make the vertebral column serve as the fixed point. Deuch² records a case of this kind, in which the ileum, as it lay across the vertebral column, just above the sacrum, suffered rupture from a kick; death ensued in twelve hours.

Fragments of bone when swallowed become less dangerous after they leave the stomach, the osseous material becoming dissolved or disintegrated by the gastric juice. The rarity of the occurrence of ob-

struction from such causes is remarkable, especially in the case of the lower animals, if we reflect upon the fact that dogs frequently swallow fragments of bone of various dimensions without any inconvenience. A case is mentioned of a female aged fifty-eight, who died of perforation of the ileum eight inches above the ileo-cæcal valve, caused by a fragment of beef-bone an inch and a quarter long, which had lodged crosswise near the constricted part of the bowel.¹

In obstruction of the small intestine, bands, the result of some previous inflammation, play an important role. They either form the bonds of union of the intestine to the omentum, to the mesentery, or to an adjacent coil, or may be lodged in openings formed by rupture of the mesentery or of the omentum. It has been estimated that nearly one-third of all cases of obstruction are due to one or more of the above causes.²

Grawitz³ has developed a theory of mechanical genesis of diverticuli colli (see p. 395, under mesenteric artery).

THE LARGE INTESTINE.

The Large Intestine (Plate LXIX.) extends from the termination of the ileum to the anus. It is divided into cæcum, colon, sigmoid flexure, and rectum.

The large intestine constitutes from one-fifth to one-fourth of the entire length of the alimentary canal. It is five feet long and one-and-a-half to two-and-a-half inches wide. Largest at its origin, it gradually diminishes in calibre until it reaches the sigmoid flexure, from which it again slightly widens at the beginning of the rectum.

Three longitudinal bands and a number of sacculations characterize the cæcum and the colon. The bands are confined to the fibrous layer, while the sacculations extend through all the coats; hence the former are seen only upon the periphery, but the latter are as well defined upon the inner as on the outer surface. After division of the bands the sacculations disappear.

The description of the colon embraces—

The Colon.	{	Cæcum.
		Vermiform Appendix.
		Ascending Colon.
		Transverse Colon.
		Descending Colon.
		Sigmoid Flexure.

¹ Lancet, 1865, ii. 183.

² Vierteljahrsschrift für Gericht. Med., Bd. xvi. H. 2.

¹ Lancet, 1860, 611.

² W. W. Wagstaffe, St. Thomas's Hosp. Rep., 1873.

³ Virchow's Arch., 1876, iv.

THE CÆCUM.—The Cæcum (fig. 1, Plate CII.) is placed between the ileum and the colon. It lies in the iliac fossa, and measures two-and-a-half inches in breadth. Behind and toward the median line of the body is the vermiform appendix. Though commonly in the same line as the ascending colon, the cæcum may form an obtuse angle with it. Its peritoneal covering is incomplete behind, thus bringing the structure in contact with the connective tissue of the iliac fossa. At times, however, it is completely enveloped by peritoneum, when a short meso-cæcum may be defined. The longitudinal coat of the ileum is continuous with that of the cæcum. The circular fibres and the mucous membrane are deflected as they pass from the ileum to the cæcum to form a pair of valve-like folds. This arrangement is termed the *ileo-cæcal valve* (valve of Baubin). It is situated at the upper portion of the inner border of the cæcum, and is composed of two transverse folds, an upper and a lower, the latter being the larger of the two. The valves are covered with villi upon their upper surfaces, but none are found on the lower. Both folds are continuous above with the ileum, while the under surface of the upper fold is continuous with the colon, the under surface of the lower fold is continuous with the cæcum. The opening between these folds is of an elliptical shape. Its anterior end is turned forward and slightly to the left, while the posterior end is narrow and pointed.

Upon either side of the narrow ends of the opening is a ridge, or doubling, termed the *frænum*; this is shorter on the inner side.

THE VERMIFORM APPENDIX.—The Vermiform Appendix is an elongated cylindrical structure continuous with the lower posterior and inner portion of the cæcum. It measures from three to five inches in length, and has the diameter of a goose-quill, but is often slightly wider at the mouth. Its walls are relatively thick as compared to those of the cæcum. The mucous lining is marked with numerous follicles and is smooth, except at its junction with the cæcum, where a well-defined fold exists. This fold is best seen in young persons from the third to the twelfth year, is inconstant in adults, and often disappears in old age.¹ Very rarely a spiral valve is found throughout the entire length of the appendix. The appendix is invested by peritoneum extending from the basal portion to the cæcum as a triangular fold, which has received the name of the *mesenteriolum* (Luschka). A portion of the ileo-cæcal fold reaches its base, beyond which is a pocket called the *ileo-cæcal recess*.

Relations.—Behind the appendix are the iliac fossa and the brim of the pelvis. In front are the inner border of the cæcum, and possibly the small intestine. To the inner side is the Psoas muscle, and to the outer side the cæcum.

As a rule, the appendix is bent once upon itself or twisted. It may be concealed beneath the cæcum, or may hang down in the cavity of the pelvis, where it has been known to effect adventitious adhesions with the pelvic organs, and even to perforate the bladder. Rarely it is lodged under the ascending colon, or deflected so as to be in contact with the abdominal wall. Cruveilhier records an instance in which it was contiguous with the liver. Other writers have mentioned the possibility of the appendix being caught in the mesentery,¹ or forming an ingredient of inguinal hernia.²

The vermiform appendix is of unknown function. It is found only in man, in the man-like apes, and in a marsupial animal—the wombat. It retains the embryonic characters of the large intestine, and is probably a rudiment of the enormous cæcum of quadrupeds of the rodent type.

Although thus structurally insignificant, its possible lesions may give rise to important clinical questions, and it is not infrequently a factor in retro-peritoneal abscess.³

THE COLON.—The Colon intervenes between the cæcum and the sigmoid flexure. It is cylindrical in form, measures about two-and-a-half inches in diameter, and is marked in common with the cæcum with longitudinal bands and sacculations. It is divided into ascending, transverse, and descending portions.

The Ascending Colon passes nearly vertically upward along the right side of the abdomen to the under surface of the liver, whence it turns abruptly to the left to form the hepatic flexure, and passes into the transverse colon. It lies in front of the right kidney.

The Transverse Colon extends across between the ascending and descending portions beginning at the hepatic flexure and ending at the splenic. It is covered in front by the root of the great omentum. As a rule it lies across the upper part of the epigastric region, although it may be lower. The peritoneal covering is complete at the transverse colon, and forms the mesocolon, which extends from the

¹ N. Y. Med. Journ., iii. series, vol. i. 1856, 328.

² Med. Times and Gaz., 1868, 316.

³ For a full discussion of this subject, see W. T. Bull, N. Y. Med. Journ., xviii. 240.

¹ Abhand. der Erlangen Phy. Med. Ges., ii. 7.

transverse portion backward to the vertebral column, and separates the stomach and the pancreas from the rest of the abdomen.

The Descending Colon begins at the splenic flexure and ends at the sigmoid flexure. It closely resembles the ascending portion, but is commonly more deeply seated, being concealed by coils of jejunum. According to Sappey, it is a little longer than the right, and is more closely related to the inner surface of the ribs.

The *structure* of the cæcum and the colon is simple. The longitudinal bands of muscle fibres are three in number, one on the inner, one upon the anterior, and the remaining one upon the posterior surface. The circular fibres are less conspicuous than in the small intestine, but present no peculiarity of interest.

The mucous membrane is thinner than in the small intestine, and is without villi. The closed glands are somewhat larger than in the small intestine, and not arranged in patches as in the ileum. They are most abundant in the vermiform appendix and the cæcum, gradually diminish in number thence within the ascending colon, and are commonly absent from the remainder of the bowel. The follicular glands, however, are everywhere numerous. Their open mouths present minute blackish points over the surface of the membrane. The epithelium is columnar.

THE SIGMOID FLEXURE.—The Sigmoid Flexure is that portion of the large intestine which intervenes between the descending colon and the rectum. As the name implies, it is conspicuous for its **S**-like form, which causes it to extend forward and downward from the left iliac fossa. It is usually described as terminating at the sacro-iliac articulation, but in this respect it is exceedingly variable. The sigmoid flexure is held by a distinct peritoneal attachment to the iliac fossa. The sigmoid flexure is the most movable portion of the large intestine. Its minute structure recalls that of the colon.

In congenital absence of the rectum, the sigmoid flexure is so often observed to be thrown over to the right iliac fossa, that Huguier has proposed to form an artificial anus through the right iliac fossa rather than the left.

REMARKS.—Under the practical remarks upon the colon may be considered (*a*) displacements; (*b*) torsion; (*c*) intussusception; (*d*) and the presence of diverticuli.

(*a*) *Displacements.*—The colon is of course most variable at the transverse portion. It normally extends across the abdomen opposite the twelfth dorsal vertebra, where it is in relation above with the liver

and the gall-bladder, and lies just in advance of the first portion of the duodenum and the pyloric end of the stomach. It also occupies in part the left hypochondriac region in front of the spleen. The colon, when the stomach is empty, lies across the anterior surface of this organ. From these normal relations it may vary so as to lie transversely across any portion of the abdomen. It may, indeed, lie so low as to be in contact at one point with the cæcum. In diseased conditions these two portions of the colon may be thus united by adhesions. In a case recorded with details by Thurnam,¹ the transverse colon was found below the umbilicus and adherent to the cæcum. An abscess had formed about the point at which the transverse colon had become fixed to the integument and a fecal fistula established. The descending colon may cross the abdomen in front of the fourth lumbar vertebra, and form an ample convolution on the right side before terminating in the rectum—an important anatomical variation to remember in the operation of opening the colon in the left groin.

The descending colon, when inclined toward the median line, with the sigmoid flexure to the left, may be associated with misplacement of the left kidney.²

Either the ascending or descending colon may be pushed inward by an enlarged kidney.³ Each may be fairly obliterated by the descent of an invagination at the ileo-cæcal valve.

With regard to the practical results following these displacements, the cæcum and beginning of the descending colon on the right side, and the sigmoid flexure or terminal part of the descending colon on the left, may be considered together. Both may be found among the contents of a hernial sac; both may be displaced to the median side; so that adhesions between the two are not among improbable lesions. Wilks has described an example of a cæcum which was found lying loose in the iliac fossa of the opposite side.⁴

The sigmoid flexure, however, from its peculiar position, and the relatively great length of its peritoneal attachments, having often a length of two-and-a-half inches, is the most liable to assume unusual positions. It may be thrown across to the right side of the abdomen, or, when loaded with feces, it may gravitate in the pelvis, when its lower portion becomes abruptly angulated with the rectum. Indeed, it would

¹ Trans. Path. Soc. Lond., 1848, 265.

² A. E. Durham, Guy's Hosp. Rep., 1860, iv. 413.

³ C. A. Hare, Med. Times and Gaz., xiv. 1857.

⁴ Med. Times and Gaz., 1862, 135.

appear likely that this is the physiological position of the flexure, since it retards the descent of the feculent matter. It is in this position that it is apt to effect adhesions with the pelvic viscera, and thus are explained those rare instances of fecal fistulæ opening into the bladder, the vagina, and even the vas deferens when the rectum is intact.

A case has been recorded by Handeside¹ in which during labor a rupture of the vaginal walls occurred. Eighteen inches of the sigmoid flexure protruded at the vulva.

According to J. Lewis Smith,² the *colon of the infant* is relatively longer and more movable than that of the adult. About one-fourth or one-third of the large intestine in children lies within the brim of the pelvis; and in speaking of the size and angulation of the sigmoid flexure in such subjects, this author advises against the insertion of a solid instrument further than one inch and a half from the anus. A. Jacobi³ asserts that there is not *one only*, but several sigmoid flexures in children, owing to the manner in which this voluminous portion of the bowel is packed in the abdominal cavity.—John Abernethy narrates an instance in which the colon of an infant was found enormously enlarged, having a large flexure in the position of the transverse colon which reached the pelvis. The small intestine was but six feet in length.⁴

The *cæcum*, while covered entirely by peritoneum, as a rule, will occasionally have an open space behind in contact with the iliac fossa. But the size of this uncovered surface is not so large as it was supposed to be prior to the researches of Luschka.⁵ By inserting the hand in either iliac fossa behind the peritoneum, the loose connective tissue can be readily pushed up toward the Quadratus Lumborum muscle. It is this locality which is so frequently the site of inflammatory processes, transmitted from the colon and pelvic organs,—the latter particularly in the female.

(b) *Torsion*.—The large intestine is more prone to twisting or irregular angulation of one portion of the bowel over another than is the small intestine. For reasons already given, the sigmoid flexure is especially liable to this lesion, one-half the recorded cases being in this portion of the canal. Next in order come the cæcum, then the ascending colon, and

finally the transverse colon.¹ A good example of strangulation of intestine following rotation of the sigmoid flexure has been given by Jacob Bigelow.²

In the coats of the large intestine, as in the small intestine, the circular fibres pertain more especially to the mucous membrane, and the longitudinal to the peritoneal coat. H. B. Sands³ records a case in which a rupture of the colon following extreme distension did not involve the mucous layer. Hyrtl⁴ describes an extraordinary lesion inflicted by a suicide who, after opening his abdomen, cut off four-and-a-half inches of the transverse colon. At the cut end of the bowel, on the right side of the wound, he seized the mucous layer with its associated circular muscular fibres, and dragged five feet of it away from its normal connections, the peritoneal covering and the longitudinal muscular fibres alone remaining within the abdomen. On the left side the mucous membrane and circular muscular fibres protruded from the external wound twenty inches.

(c) *Intussusception*.—This is less frequently seen in the colon than in the small intestine. The mechanism, however, is the same. A case is described by A. Jacob,⁵ of invagination of the descending colon in an infant, in which repeated hemorrhages took place in the transverse colon. Harrison⁶ noticed an unusual form of this lesion, which consisted of the invagination of the transverse colon by the descending colon. The tumor created by the inclusion was about the size of an orange, freely movable, and situated between the umbilicus and the left ribs.

Obstruction of the colon may follow enormous deposition of fat beneath the peritoneum.⁷

(d) *The presence of Diverticuli*.—No true diverticuli occur in the large intestine; false examples, however, are occasionally met with. Sydney Jones⁸ has recorded an interesting case of a male sixty-four years of age, who had suffered for years from a fecal fistula communicating with the bladder. At the autopsy it was found that the sigmoid flexure was contracted, and from among a number of false diverticuli of unequal length extending from this portion of the large intestine, one had effected entrance into

¹ Edinburgh Med. and Surg. Journ., 1873, xviii. 658.

² New York Med. Journ., x. 253.

³ Sel. in Boston Med. and Surg. Journ. vi.

⁴ Philosoph. Trans., 1809, xvii. 277 (figs.).

⁵ Archiv für Path. Anat., xxi. 285.

¹ W. Brinton, Intestinal Obstruction, 1884, 84.

² Boston Med. and Surg. Journ., 1841, July 5.

³ New York Med. Journ., xix. 622.

⁴ Topograph. Anat., i. 686, where reference is made to *Wochenblatt der Zeitschrift der ärztlichen Gesellschaft in Wien*, i., No. 8.

⁵ New York Med. Journ., 1858, 355.

⁶ Dublin Med. Press, 1845.

⁷ H. Lenox Hodge, Trans. Path. Soc., Phila., 1877.

⁸ Trans. Path. Soc. London, 1859, 132.

the bladder. Within the latter organ was found a phosphatic calculus the size of a horse-bean, having a nucleus of fecal matter.

Bloodvessels.—For the arteries of the small and the large intestine see the account of the branches of the abdominal aorta. The veins are tributary to the portal system of veins.

Nerves.—The nerves are derived from the pneumogastric nerve and from the superior mesenteric plexus of the sympathetic system.

Lymphatics.—The lymphatics join the mesenteric glands.

THE RECTUM.

The Rectum (fig. 4, Plate CL.; fig. 1, Plate C.) is that portion of the large intestine placed between the sigmoid flexure and the anus. As the name implies, it is straight, or at least relatively so; but when carefully examined the rectum is found to incline slightly from the left sacro-iliac symphysis to the median line of the sacrum opposite its third segment. Thence it descends, following the general curve of the sacrum. Within an inch of its termination the bowel is turned slightly backward to end at the anus. In addition to these deviations from a straight line, the rectum presents two lateral curves, one slight curve to the left side opposite the third segment of the sacrum, the other lower down, which inclines to the right.

For convenience of description, the rectum is divided into three portions, namely, the *upper*, the *middle*, and the *lower portion*.

The *upper* portion is one-half inch long, is entirely embraced by peritoneum, and connected to the sacrum by the meso-rectum, which carries the inferior mesenteric artery and vein, together with nerves and lymphatics. Behind are the sacro-iliac junction, the Piriformis muscle, branches of the left internal iliac artery, and the origin of the sacral plexus.

The *middle* portion, which is three inches long, is in contact with the peritoneum only upon its anterior surface. Behind it are the lower portion of the sacrum and the corresponding part of the Piriformis muscle. In continuing its curve forward it lies upon the coccyx and the muscular fibres arising therefrom. In front it is in relation with the base of the bladder, the vesiculæ seminales, the vasa deferentia, and the prostate gland. In the female it is in relation with the posterior surface of the bladder.

The *lower* portion, one inch long, is without peritoneum, and is surrounded by the fat of the ischio-rectal fossa. Its lower portion is embraced by the External Sphincter muscle. In front lie the membra-

nous and bulbous portions of the urethra in the male, and of the vagina in the female. By the deflection of the third portion backward a triangular space is defined between the pudenda and the rectum.

Structure.—The minute anatomy of the rectum is much simpler than that of the small intestine, but is more complicated than that of the colon or of the sigmoid flexure. The canal presents an imperfect peritoneal layer already noticed, a muscular layer composed of longitudinal and circular fibres, a submucous layer, and the mucous membrane.

The muscular layer. The longitudinal layer of muscular fibres is paler than the circular, but better developed than in the colon. It is gradually lost toward the lower end of the rectum. A few fasciculi extend below the others and end in tendinous threads which, penetrating the fibres of the External Sphincter, are lost in the subcutaneous connective tissue. These bands correspond to the longitudinal folds of the rectum as seen upon the mucous membrane. Others of the fasciculi are inserted in the pelvic fascia, and a few upon the sacro-coccygeal ligament.—The circular fibres are better developed than the preceding. They end just above the anus in a well-defined edge termed the Internal Sphincter. As elsewhere through the alimentary canal, the circular layer is more intimately held to the mucous layer than to the longitudinal fibres.—The Tertiary Sphincter is a name occasionally given to the circular fibres at the beginning of the rectum. (See Remarks.)

The submucous connective tissue is abundant, and contains elastic tissue and lymphatic vessels. In it are imbedded the glands of the mucous layer.

The mucous membrane.—The mucous membrane bears in color and general appearance a resemblance to that of the cesophagus, and presents at its lower portion obscure reticulations recalling those seen on the mucous lining of the empty stomach. Near the anus it is provided with a number of folds, the most conspicuous of which are the longitudinal folds or columns of Morgagni which are seen at the lower part of the rectum. They correspond in position to well-marked fasciculi of the longitudinal muscular fibres, and in the contraction of the External Sphincter are prolonged to the verge of the anus. The lower ends are united by transverse folds which convert the intervals between the columns into pouches. At the junction of the upper and middle portions an oblique fold is seen, known as the valve of Houston.—The epithelium of the rectum is columnar, except at the anus, where it is squamous.

The glands of the rectum are few in number, and

of the racemose type. Immediately about the anus the glands are of the sebaceous variety.

Bloodvessels. The arteries of the rectum are the superior hæmorrhoidal, from the inferior mesenteric; the middle hæmorrhoidal, from the internal iliac or the internal pudic; and the inferior hæmorrhoidal, from the internal pudic. The first-mentioned is the most important of these vessels. It generally extends almost the entire length of the rectum; the middle hæmorrhoidal artery anastomoses with it. The inferior hæmorrhoidal is a small artery, and is for the most part distributed to the External Sphincter muscle and to the region of the anus. The veins join the internal hæmorrhoidal veins.

Nerves. The nerves are derived from the superior hæmorrhoidal plexus.

Lymphatics. The lymphatics join the lumbar glands.

Variations.—In some form of double monster with a single anus, each individual separately uses the orifice, *i. e.*, two sigmoid flexures join the rectum.

REMARKS.—The three portions of the rectum above-mentioned serve as the best guides for the arrangement of its medical relations.

The first portion, by reason of its peritoneal investment, is in all its features an abdominal viscus. It is furnished with bloodvessels, nerves, and lymphatics from the same source as the colon; the colon presents no structural peculiarities not possessed by this portion of the rectum, except the longitudinal bands and sacculi. It is in this portion of the rectum that an occasional unusual development of the circular fibres retards the descent of the feces from the sigmoid flexure. In examples of loss of power of both the Internal and External Sphincters, incontinence of feces need not, therefore, occur, since periodic evacuations of the lower rectum may be entirely controlled. That such control, however, is not the rule is unfortunately too true, as many sufferers from impairment of the office of the lower sphincter can testify.—This portion of the rectum is very rarely the seat of organic stricture. According to H. Storer, ovarian cysts have been known to open into it.

In a state of health the rectum is empty, and its walls are in contact. The feculent matter lodged in the sigmoid flexure is in great part controlled, as already seen, by the circular fibres there situated, and its escape thence announces the desire for defecation. The fact, however, that in practice the rectum is so rarely found empty is proof of its frequent assump-

tion of the office of a reservoir for feces. The habit of constipation, while demanding of the rectum a new function, lays the foundation of the great majority of its diseases.

The second (middle) portion of the rectum, since it is free from peritoneum at its lateral and posterior surfaces, is liable to compression from alterations in the loose connective tissue about it. Travers¹ describes a narrowing of this portion of the gut by dense fatty tissue, with subsequent ulceration into the peritoneal cavity.

The third portion is entirely free from peritoneum, and is in such intimate relations with the pelvic organs that its medical relations are of great importance.

The spaces behind and at the sides are occupied by delicate fat, which is continuous with the subcutaneous fat of the trunk and thighs. The yielding character of this tissue enables the rectum to be distended to a considerable distance without pressure upon any resisting point. In this way large quantities of fecal matter may be retained with comparative impunity. Prolonged irritation in the rectal walls will transmit to the connective tissue of the ischio-rectal fossa the exciting causes of inflammatory mischief, which, all things being equal, will exist in degrees of frequency proportionate to the violence of the initial trouble and the amount of extra-rectal fat. Persons who have large visceral organs, and whose abdominal walls and omentum are heavily loaded with fat, will often suffer from ischio-rectal abscess, due to portal congestion, and its resultant chronic rectal stasis. In the emaciated, an irritation is transmitted to the outside tissues from the partial or complete absorption of the fat. The physiological office accomplished by the latter tissue being in such patients absent, the distension of the bowel is accompanied with more or less friction, which not infrequently results in abscess. Thus, pus may form in the ischio-rectal fossa as the result of apparently opposite conditions, and in two classes of subjects whose physical appearances are strongly contrasted.

The ischio-rectal fossa is occasionally the seat of extensive traumatic injury. Thus, a male aged forty years inadvertently sat down upon a conical oil-feeder for machines, the nozzle of which was five inches long; the ischio-rectal fossa was penetrated to a distance of four-and-a half inches, and, as a conse-

¹ Medico-Chir. Trans., xvii. 361.

quence, a large abscess was developed. The condition was successfully treated by dividing the External Sphincter.

In another instance, a penetrating wound of the rectum, produced by a stick forced up the rectum, caused gluteal abscess, from which escaped portions of the offending agent. In females, the lower portion of the rectum may be exposed by forcing the recto-vaginal septum backward and downward by digital pressure. In this way the anterior wall of the rectum can be temporarily forced through the anus, "like the finger of a glove," and thoroughly explored. In order that this procedure should be effective, it is best to rupture the External Sphincter by forcible dilatation with the fingers, a procedure originally proposed by Recamier and revived by W. H. Van Buren, of New York.¹

The *terminal* portion (anal portion) of the rectum is in intimate relation with the cutaneous structures. It lies directly behind the prostate gland at first, but is soon deflected thence downward and backward, leaving between its anterior wall and the membranous portions of the urethra a triangular space.

The anus, being surrounded by the External Sphincter, is closely corrugated. It is slightly relaxed in the act of bearing down, so that the finger can be best inserted for examination of the rectum at such a time. Dr. Marion Sims² recommends that the patient be placed in the genu pectoral position, a posture certainly favoring the removal of all visceral pressure, and relaxing the External Sphincter. Dr. T. Gaillard Thomas³ has suggested a similar procedure for making topical applications in rectal ulcers from chronic dysentery.

A healthy anus is well drawn up in the groove between the buttocks, and is, when the patient stands in the erect position, directed slightly backward. The finger being introduced meets with but moderate resistance. Turning the finger forward and backward, a capacious chamber is detected beyond the anterior wall of which lie the membranous portion of the urethra and the prostate gland.

An ischio-rectal abscess, however formed, is the precursor of a fistulous orifice either in the rectum or in the perineum. If the rectum be examined before the abscess opens, the bulging wall of the collection can easily be detected. This is especially noticeable in fat subjects, and it is with them that the collection is apt to open in the rectum, since this limiting wall

is the least resisting. When the rectum is contracted and the surrounding parts defective in fat the integument is the least resisting, and the abscess-opening appears externally.

As an evidence that a knowledge of the anatomy of this region is essential to a true conception of its pathological processes the fact may be cited that anal fistule sometimes penetrates the fibres of the External Sphincter or Levator Ani muscles, or enters the rectum between this muscle and the Internal Sphincter.¹ The modern French writers assert that anal fistule always exists near the anus. It certainly may be expected to be found at or about the External Sphincter, although no conclusion with respect to this point can be considered as exact.

The anatomical features of each case of fistule must be separately considered. The so-called horse-shoe fistule, having a semicircular disposition around the bowel, but with a single opening into it, also the various forms of fistule confined to the coats of the rectum and particularly to the space between the circular and longitudinal muscular layers, are occasionally seen. They have been traced as far as the sigmoid flexure.

In rare instances the opening of communication between an ischio-rectal abscess and the bowel is so large that the feces have been forced through and have formed an ingredient of the ischio-rectal collection. Of this exceedingly dangerous form of fistule, L. A. Sayre² has described a good example in the person of an adult male, who, while suffering from a fistule on the left side, was subjected to the risks attending a fecal abscess occupying both ischio-rectal fossæ. The pressure to which the surrounding parts were subjected caused denudation of the tuberosities of the ischium and the left sacro-sciatic ligaments and coccyx, the latter in addition being detached from the sacrum.

The position of a fistulous orifice near the rectum should never be accepted as an evidence of rectal disease. It is certainly a probable inference that the rectum is involved if the opening is behind or at the sides of the anus, but an improbable inference if it is in front, since such openings in the latter locality are more apt to be a complication of peri-urethral or prostatic abscess, or even of pelvic inflammation.

The practical points worthy of attention in studying the *coats of the rectum* relate chiefly to the mucous membrane and the space between the circular and the longitudinal muscular coats.

¹ H. Storer, Amer. Journ. of Obstetrics, 1868, i. 369.

² Diseases of Rectum.

³ N. Y. Med. Journ., 1875.

¹ Diseases of Rectum, Holmes's Syst. of Surg., 199, 202.

² New York Journ. Med., 1854, 178.

The mucous membrane of the first portion of the rectum does not differ from that of the sigmoid flexure. At the beginning of the middle portion, however, the variable oblique folds of Houston are seen. In the lower portion the folds are constant and longitudinal, and aid in limiting the rectal pouches. Below these is seen the flask-shaped end of the rectum, and at the terminus of the bowel are seen the corrugations of the anus.

The mucous lining of the rectum above the anus in the position of the longitudinal folds and the pouches is liable to a variety of local diseases. The normal amount of mucus lodged therein is capable of being enormously increased, as in chronic affections of the rectum. The pouches themselves are occasionally the site of cyst-like collections, and may also afford lodgment for seeds, fragments of bone, etc.

Stricture of the rectum is apt to be located either at the upper portion near the oblique fold of Houston or near the lower part at the longitudinal folds or pouches of Morgagni. The last-mentioned locality is almost universally the seat of the so-called venereal stricture so common in females. In twenty-one out of twenty-eight cases treated by T. Curling,¹ the stricture was within an inch to an inch-and-a-half of the anus.

Polypi also occupy almost exclusively the lower portion of the rectum. They are rarely found higher up than an inch or an inch-and-a-half above the anus.

Internal hæmorrhoids protrude in defecation and carry with them the mucous membrane.

Prolapsus of the rectum invariably takes place between the longitudinal and circular muscular fibres, which in the rectum preserve the same mutual relations as those already noticed in the colon, so that the longitudinal fibres remain in position, while the mucous membrane and the circular fibres descend.

Brodie mentions a case in which the intestine protruded at the anus, having effected entrance into the rectum by a slit on its anterior surface.

Knowledge of the position and course of the rectum is of importance in introducing a bougie or the nozzle of the enema syringe into the bowel. Cases have been recorded in which the intruding instrument was forced through the rectum into the peritoneal cavity or between the rectum and the sacrum. There is preserved in the museum of St. Bartholomew's Hospital, London, according to T. Bryant,² a specimen of the former lesion, in which the contents of the

syringe had been introduced into the peritoneal cavity, where they were found after death.

A depression in the anal region and the position of the genitals far back would lead to the inference that the rectum was absent.¹

Longitudinal defects of the rectum consist either in retention of the embryonic state of the uro-genital sinus, with the rectum opening into it, or else in the rectum being defective in whole or in part.

The rectum has been known to open into the bladder or vagina, conditions which make it possible for life to be sustained.

In much more frequent examples, it ceases to exist as a canal, and the space between its cul-de-sac and the perineum is occupied by fibrous tissue. The lower end of the bowel may be insensibly lost in the general tissue of the parts, or may be completely invested in peritoneum and possess a mesorectum. When the rectum is obliterated at its first or second portions, no trace of the position of the anus is usually discoverable. But when it is continued near to the skin the anus is more or less well defined, and may be almost as in the normal state save that it is impervious. In such a condition the acts of crying, coughing, etc. will cause the anus to bulge and move slightly downward.

The large intestine may end at the middle of the transverse colon, as occurred in a reported case.² The anus, strange as it may appear, was patulous, admitting the finger one half an inch. The child lived nine days.

The skin about the anus is tightly adherent to the External Sphincter. In the relaxed condition of the parts due to protrusions, as in internal hæmorrhoids and prolapsus, the skin forms a small basal covering to the mass. When the tumor is restored to the bowel, the skin in question remains around the margins of the anus in loose pendulous folds. In operations on the anus these folds of skin should never be removed or included in a ligature, since it has been shown that the formation of a cicatrix therein is accompanied with excessive contraction, sufficient, if at all extensive, to lead to narrowing, and indeed to partial obstruction of the anal orifice.

THE LIVER.

The Liver (figs. 2 and 3, Plate CII.; figs. 1, 4, and 5, Plate C.; fig. 1, Plate LXVIII.) is the organ for the secretion of bile. It is an appendage to the alimentary canal, yet it holds such peculiar relations both

¹ Diseases of Rectum, 4th ed., 122.

² Practice of Surgery, 345.

¹ Curling, *ibid.* 201.

² Lancet, i. 1839, 794.

to the portal vein and to the vena cava, and by means of the latter empties its return-blood at a part of the inferior vena cava in such close proximity to the heart, that in one sense the liver is also an appendage to the bloodvessel system. Thus, it holds a double relation, one to alimentation, and the other to sanguification. In the last-named group of functions may be included that of glycogenesis. Its color is of a dark reddish-brown.

The liver is situated in the right hypochondriac region, extending thence to the left. Above it lies the Diaphragm; below it lie the kidney, the hepatic flexure of the colon, part of the transverse colon, the pyloric portion of the stomach, and the larger part of the anterior surface of that organ. Behind it lie the inferior vena cava, the aorta, and the vertebral column; while behind, and to the right side, and in front it is embraced by the last six or seven ribs, with their intercostal cartilages.

In front the anterior edge can be felt through the abdominal walls in thin persons. The liver is chiefly fixed to the Diaphragm by intervening connective tissue; but its pendulous parts are held in position by folds of peritoneum termed ligaments, while the whole is buoyed up by the intestines.

The relations of the liver vary according to the position of the body and the state of the lungs. When the body is recumbent, the liver ascends from one to one-and-a-half inch; when the body is in the sitting posture, it descends.

In *inspiration*, the liver, according to Sibson, is not only lowered about half its height, but its summit is flattened—the entire organ gaining in width by being shortened from before backward. Instead of being protected by the ribs and cartilages, it is now thrown forward so as to be more prominent than the seventh or eighth costal cartilage, and the xiphoid cartilage, by from one-half of an inch to one inch. The præcordial space in expiration is somewhat resonant on percussion, but, by the movement of the liver just noted, the percussion note over the præcordial space may become dull.

In *expiration* the liver ascends so as to be almost entirely concealed within that portion of the abdomen defined by the false ribs.

The position of the lower border of the liver will vary in different individuals, owing to normal variations in shape; it may lie two or three inches above the umbilicus; or a small portion of it only may be found to extend below the xiphoid cartilage. Accordingly, the lower edge of the liver is not an infallible guide to the size of the organ.

The liver is placed somewhat obliquely from before backward in such wise that the lower surface tends to look slightly forward as well as downward, a tendency which is increased by the shape of the stomach in repletion.

The shape of the liver is that of the upper segment of an ovoid cut obliquely lengthwise; the larger end lying to the right, from which position it narrows toward the left in all directions.

The liver measures ten to twelve inches from side to side (frontal section) by six to seven from before backward (sagittal section), and is three-and-a-half inches deep. Its weight is from one and a half to four pounds. It may even reach a weight of seven and three-fourths pounds.¹

The surfaces of the liver are two in number, a superior and an inferior; the borders are four in number: the anterior, the posterior, the external, and the internal.

The *superior surface* is smooth and convex, and answers to the general curve of the right side of the Diaphragm; beyond this point to the left it is flattened; to the right it is compressed by the false ribs, and behind it is continuous with the broad excavation for the vena cava.

The *inferior surface* is nearly flat, and presents a complicated relation of parts. To the left of the centre of the organ, extending across it from before backward, is the *longitudinal fissure*, the anterior

¹ D. Cunningham, Journ. of Anat. and Phys., 1879, 509.

EXPLANATION OF PLATE CII.

Fig. 1. A drawing of a dried preparation, which is designed to show the ileo-cæcal valve.

Fig. 2. The liver, seen from beneath.

Fig. 3. The liver, seen from above.

Fig. 4. A diagrammatic representation of the pancreas and duodenum in position to the vertebral columns, ribs, and the great vessels of the abdomen.

Fig. 1.

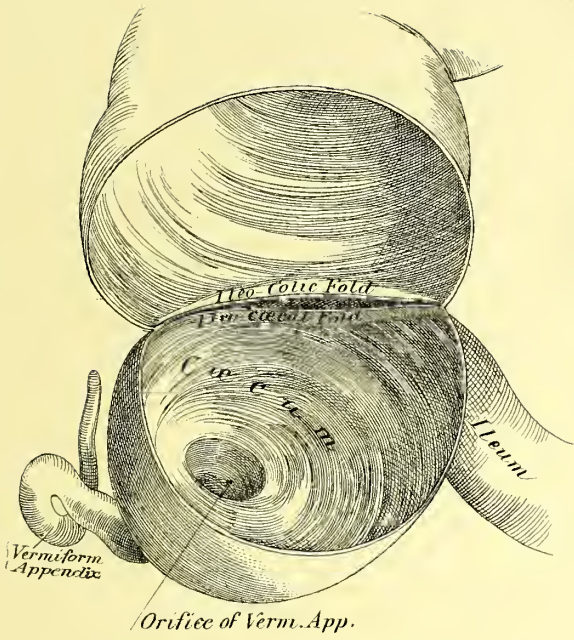


Fig. 2.

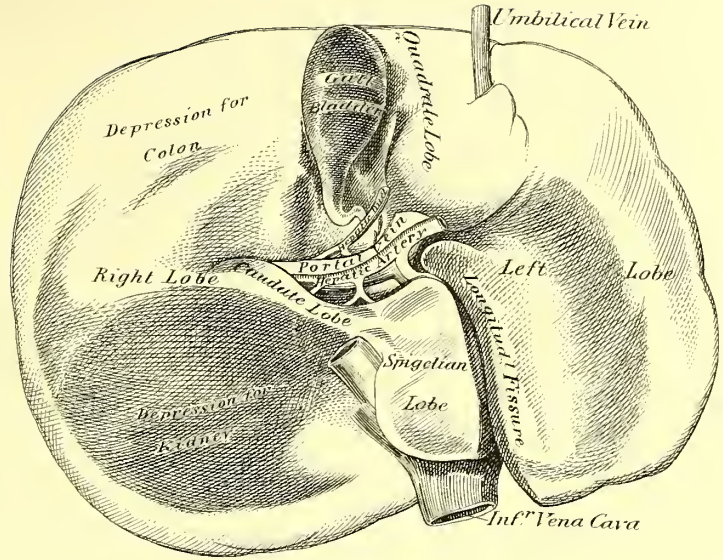


Fig. 3.

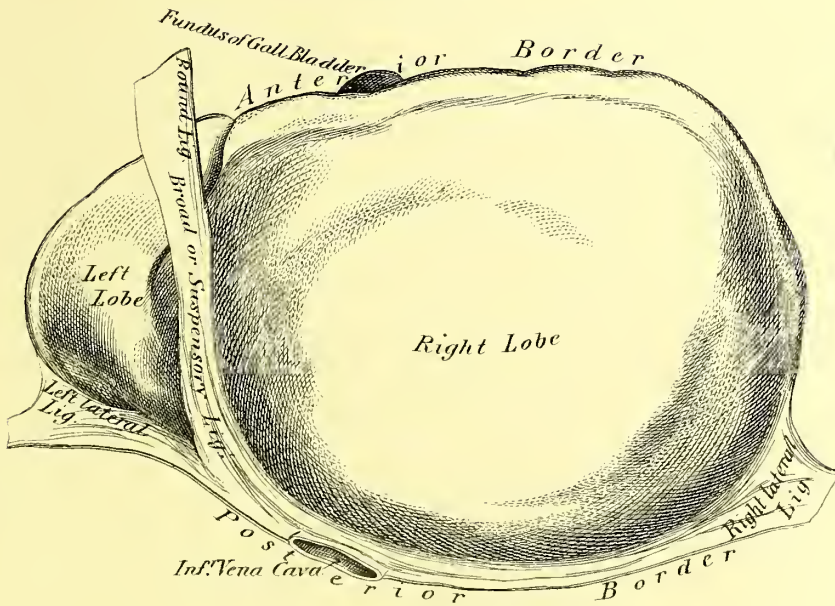
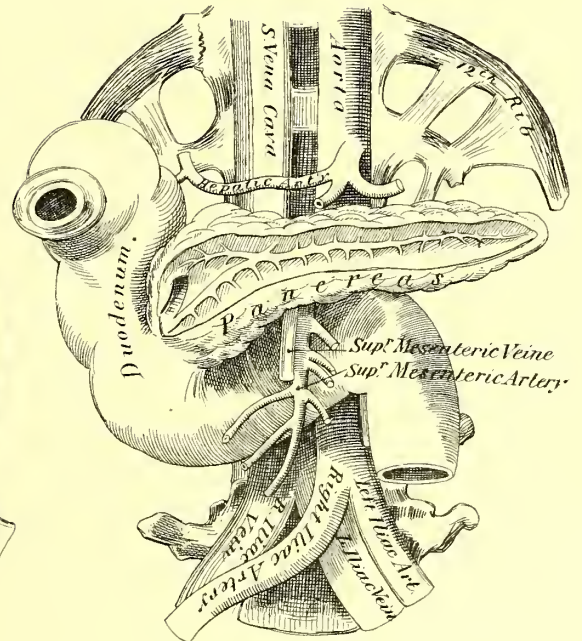
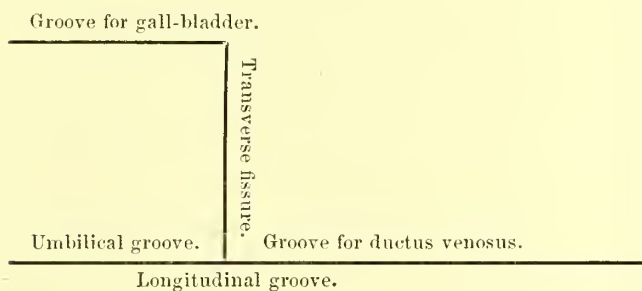


Fig. 4.



portion of which is occupied in the foetus by the umbilical vein, and hence it is sometimes called the *umbilical groove*; across the posterior portion passes the obliterated ductus venosus, accommodated within the *groove for the ductus venosus*. Corresponding to the position of the gall-bladder is a groove known as the *groove for the gall-bladder*. Joining the extremities of the groove for the gall-bladder and the umbilical groove, is the *transverse fissure*. This lies in the middle of the under surface, measures twelve to fifteen lines in length, and accommodates the hepatic artery, portal vein, hepatic duct, and lymphatics. At the posterior border, and answering to a line continuous with the groove for the gall-bladder, is a small oblique *groove for the vena cava*.

The figure resulting from the union of the above-named fissures has been compared to the letter h, thus:—



In some specimens the groove for the vena cava is near the transverse fissure, when an H-like figure results. This is the normal arrangement according to Cruveilhier.

The under surface of the liver is marked by three shallow depressions for the right kidney, the colon, and the right supra-renal capsule.

When the liver is hardened in position it is seen that the figure above described is more or less conventional. The portion of the upper surface not covered with peritoneum, the Spigelian lobe, and the greater portion of the under surface of the left lobe look directly backward. These portions have been included by His in a posterior surface of the liver.

The Hepatic Notches.—The anterior border is marked by a notch for the umbilical vein. The posterior border is broadly notched or excavated by the vena cava and the vertebral column. Small bridges of hepatic tissue are apt to extend across the groove for the umbilical vein and the vena cava.

The Hepatic Lobes.—The under surface of the liver is divided into five lobes as usually described, viz., the right, left, quadrate, Spigelian, and caudate.

The umbilical fissure, and the groove for the dorsal vertebræ, separate the left lobe from the right. The umbilical fissure, the transverse fissure, and the groove for the gall-bladder separate the quadrate from the right lobe.

The groove for the remains of the ductus venosus, the groove for the vena cava, and the transverse fissure, separate the Spigelian lobe from the right lobe. Passing from the former to the latter is a small process of hepatic substance which has received the name of the caudate lobe.

The remainder of the under surface, *i. e.*, that portion to the right of the groove for the gall-bladder, and the upper surface from the interlobular notch to the right border, belongs to the *right lobe*.

Thus, of the five lobes, only the right and left are seen from above; and of the five the left is the most distinct; while the quadrate, Spigelian, and caudate are really differentiations from the under surface of the right lobe. These last-named lobes may be briefly defined as follows: the *quadrate* lies in front of the transverse fissure, between the umbilical fissure and the fissure of the gall-bladder. It presents a uniform flat surface. The *Spigelian* lobe lies behind the transverse fissure between the groove for the ductus venosus and the groove for the vena cava. It projects as a flattened semilunar process downward and backward, and is embraced by the lesser curvature of the stomach; its lower free surface corresponding to the upper border of the pancreas.—The Spigelian lobe is connected through a long isthmus or *caudate process* or lobe with the under surface of the right lobe. In front of the caudate process is the transverse fissure; behind it is the groove for the vena cava.

The Hepatic Ligaments.—The liver is not enveloped in the peritoneum, but has the posterior border free; this surface is in contact with the Diaphragm. The several folds of the peritoneum belonging to the liver are termed ligaments. These are as follows: the coronary, the lateral, the suspensory, and the round ligaments. To these may be added the gastro-hepatic omentum and two others, which are less defined, extending respectively from the liver to the kidney and to the colon.

The *coronary ligament* is the line of reflexion of the peritoneum from the Diaphragm to the upper surface of the liver on the one hand, and from the Diaphragm to the under surface on the other. Its main extent answers to the upper border of the posterior free surface of the liver.

The *lateral ligaments*, right and left, are triangular reflexions from the Diaphragm to the liver. The left is the longer and more slender, and lies in front of the œsophagus, by which it is slightly impressed. The right ligament lies in front of the vena cava, and extends from the middle of the right border to the Diaphragm.

The *suspensory ligament* is a falciform fold of the peritoneum, produced at a right angle from that membrane, where it joins the upper portion of the coronary ligament. It is broader in front than behind, and extends from the region of the umbilicus upward along the sheath of the Rectus muscle. It lies between the dorsum of the liver and the parietes of the abdomen and vault of the Diaphragm, at the line answering to the division of the liver into the right and left lobes.

The *round ligament* is the remains of the umbilical vein; it exists as a rounded cord which lies within the anterior border of the suspensory ligament, but leaves it to enter the umbilical groove of the longitudinal fissure, within which it lies.

The remaining folds of the peritoneum are best described in connection with the Peritoneum, *q. v.*

Structure.—The minute anatomy of the liver is exceedingly intricate. The following outline of its general plan is presented, both as to its bloodvessels and structure.

The liver, after eliminating certain products from the portal blood, returns it to the general circulation by the hepatic vein. This, the essential blood transit through the organ, is supplemented by the hepatic artery, which supplies the liver with the blood of nutrition. The terminal branches of the hepatic artery are received within a capillary network whose branches empty into the radicles of the hepatic vein; the blood, therefore, from both the portal vein and the hepatic artery empties by means of this common network into the hepatic vein. Between the cells held in the meshes of this network the bile-ducts begin.

There are thus two distinct afferent trunks to the liver, the portal vein and the hepatic artery; and two distinct efferent trunks, the hepatic vein and hepatic duct.

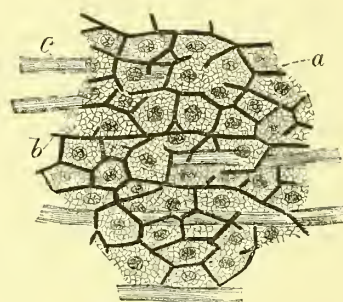
At one point, *i. e.*, in the capillary network, an element of each of these structures is found, where the afferent trunk terminates, and the efferent trunk begins. The minute anatomy of the liver will now be examined in detail. Surrounding the portal vein, the hepatic artery, and the hepatic duct at the transverse fissure, is a connective-tissue membrane known as the capsule of Glisson. A layer of connective tissue can be demonstrated lying in the interval between the coronary ligaments, at the surface at which the liver is adherent to the Diaphragm, and between the folds of the lateral ligaments.

The general surface of the liver is smooth, differing in this respect from other glands; if, however, the surface be ex-

amined with care, it is seen to be composed of minute spheroidal or polyhedral bodies called the lobules or acini of the liver. Each lobule measures transversely from one-half of a line to one line in diameter.

The delicate spaces between the lobules are termed the interlobular spaces. The lobules, together with the bloodvessels and hepatic ducts, make up the substance of the liver

Fig. 178.



From a lobule of the liver of a rabbit, in which blood and bile-vessels had been injected. *a*, liver-cells; these are well shown as nucleated polygonal cells, each with a distinct reticulum; *b*, bile capillaries between the liver-cells; *c*, capillary bloodvessels.

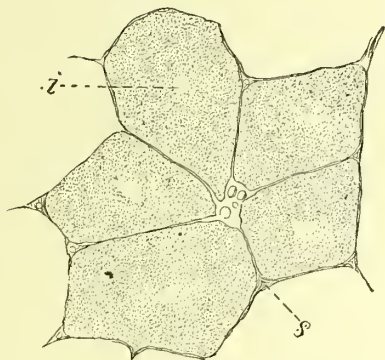
The walls of the bloodvessels within the liver are so thin that the liver is readily torn, the surface resulting being irregular and mottled. The centre of each lobule presents in a state of health a light yellow color, the border a dark brown shade; so that the general appearance of the cut surface of the organ is of a mottled shade of brown. The proper substance of the liver is composed of the *hepatic cells* (Fig. 176). These are of an irregular polyhedral form, and present a diameter of from $\frac{1}{1080}$ to $\frac{1}{345}$ of an inch. They are furnished with a nucleus, and contain a soft granular parenchyma and free oil globules. They are of a faint yellow color when isolated, but when massed yield the darkish-brown color characteristic of the liver.

In tracing the course of the vascular trunks and hepatic ducts within the liver, it is found that the portal vein, as it enters at the transverse fissure, abruptly divides into a number of vessels lying within the so-called portal tracts or canals, which each contain a portion of the trunks of the portal vein, the hepatic artery, and the bile-duct. These ascend nearly vertically through the substance of the liver, crossing the radicles of the hepatic vein at right angles. The branches of the latter vessel converge to the main trunk, which escapes at the posterior border of the liver to join the ascending vena cava. The arrangement of the two veins has been compared to two trees, whose trunks are at right angles, and whose terminal branches interlace. The hepatic artery and the hepatic duct accompany the portal vein through its general course, while the hepatic vein is without accompaniment.

The mechanism of the circulation of the liver can be best explained by directing attention to what takes place in the lobules. Each lobule is a miniature liver, having at its periphery between the lobules branches of the portal vein and

hepatic artery (interlobular branches), which freely intercommunicate and form through the lobule, between its periphery and centre, a capillary network. Directly at the centre the venules of this network (intralobular vessels) converge to form radicles of the hepatic vein.

Fig. 179.



From a section through the liver of pig. Five lobules are shown. They are well separated from one another by the interlobular tissue. *z*, interlobular connective tissue, containing the interlobular bloodvessels, *i. e.*, the branches of the hepatic artery and portal vein, and the interlobular bile-ducts; *i*, intralobular or central vein.

Within the same space in which this change of arterial to venous blood is being effected, the bile-ducts take their origin, and are directed towards the periphery of the lobule.

THE EXCRETORY APPARATUS.

The Hepatic Excretory Apparatus consists of the

Hepatic Ducts.

Gall-bladder.

Cystic Duct.

Common Biliary Duct.

The Hepatic Ducts (bile-ducts), as they lie in the interlobular spaces, are well-defined canals having a fibrous coat with abundant elastic tissue, and a mucous membrane furnished with columnar epithelium. Everywhere, from this point downward, as they converge, the ducts are furnished with numerous glandular appendages in the form of lobated mucous follicles. These follicles in some of the larger ducts are so large and numerous as almost to conceal the main duct, and have been supposed by Henle to be the essential generators of the bile, while to the hepatic cells he would restrict the glycogenic function.

In following the majority of authors in believing the bile to be generated by the hepatic cells, it must be conceded that the bile as eliminated by the cells receives valuable accessions, probably of a viscid character, from the mucous glands, in the same manner

that the seminal fluid receives additions from the glands appended to the urethra.

The Gall-Bladder is the reservoir for the bile. The organ lies in the groove of corresponding name situated between the quadrate and right lobes. Its shape is pyriform, its base being directed forward, its apex backward and slightly to the left. The fundus of the gall-bladder projects somewhat beyond the free border of the liver about opposite the tenth costal cartilage. Its apex, through the cystic duct, joins the hepatic duct at an acute angle to form the common biliary duct.

The gall-bladder measures from three to four inches in length, and one-and-a-half inch in breadth at the fundus. It has a capacity of from one-half to one-and-a-half fluidounce. In diseased conditions these measurements are materially modified. Murchison, for instance, cites an example of a gall-bladder seven inches in length.

The gall-bladder possesses three coats including the *peritoneum*, which, as a rule, envelops the under and lateral portions only. An example of complete peritoneal investment with defined meso-cystic fold is described by Hyrtl.¹ The upper surface lies in contact with the under surface of the liver, and is connected with it by a quantity of fine connective tissue. The remaining coats of the gall-bladder are the *fibrous* and *mucous* coats: the former of these presents no peculiarity; the latter is remarkable for the minute reticulation everywhere present upon its inner surface, and also for being stained by the bile a dark greenish brown color. The epithelium is of the columnar variety. A few non-striated muscular fibres may be discerned in the walls of the gall-bladder. The *relations* of the organ are as follows: The fundus is in contact with the abdominal parietes near the tenth costal cartilage. The under surface lies upon the transverse colon, which fact can be often ascertained after death by this organ being discolored at the point of contact. Near its apex the under surface may touch the pylorus or first portion of the duodenum.

The Cystic Duct as it leaves the gall-bladder is bent twice abruptly upon itself like an italic *S*, but subsequently becomes straight. It is directed downward and inward. As above noted, it joins the hepatic duct at an acute angle. This duct is furnished with minute valves, varying from five to twelve in number, which are arranged in the form of

¹ Topog. Anat., i. 708.

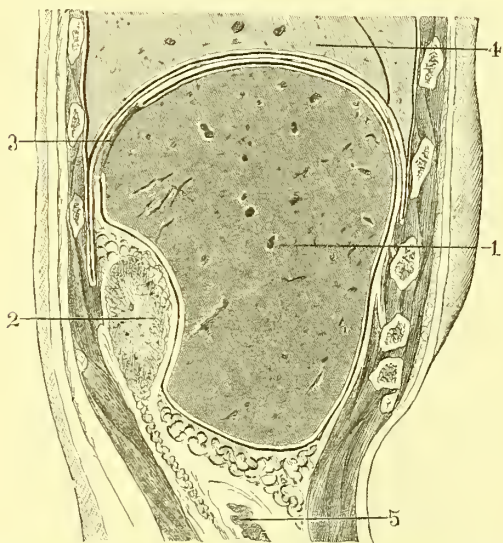
a spiral. According to Cruveilhier, they are irregular, alternate, and oblique.

The flow of bile from the gall-bladder outward is retarded in two ways: 1st. By the flexure at the apex which is due to fixation by the peritoneum, and which is readily effaced. 2d. By the valves within the duct, which are permanent.

The capillaries occupy the lobules, from the centres of which the venous blood escapes. The bile-ducts originate from above the hepatic cells, among the capillaries, and pass to the periphery. The manner of the elimination of the bile has been variously described. According to Leidy, whose researches were the first undertaken to prove the unity of construction of all gland tissue, the liver is a congeries of follicular glands which freely anastomose at their lower closed extremities, securing a reticular arrangement of tubes of basement membrane lined with hepatic cells. Beale has successfully demonstrated in the pig the existence of a system of interlobular tubes inclosing the hepatic cells. Chrzonszczewsky also has proved that there are canals among the hepatic cells.

The hepatic artery, in addition to supplying the lobules, yields branches to the portal canals or tracts, to the walls of the biliary ducts, and to the capsule of Glisson.

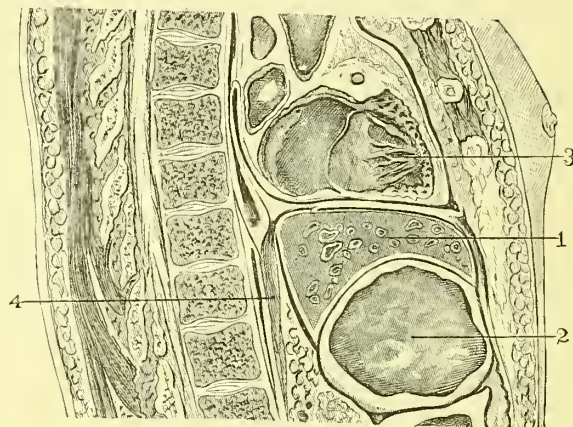
Fig. 180.



An antero-posterior (sagittal) section of the trunk in the mammary line. 1, liver; 2, right kidney; 3, the surface of the liver in contact with the Diaphragm; 4, the lower lobe of right lung; 5, ascending colon.

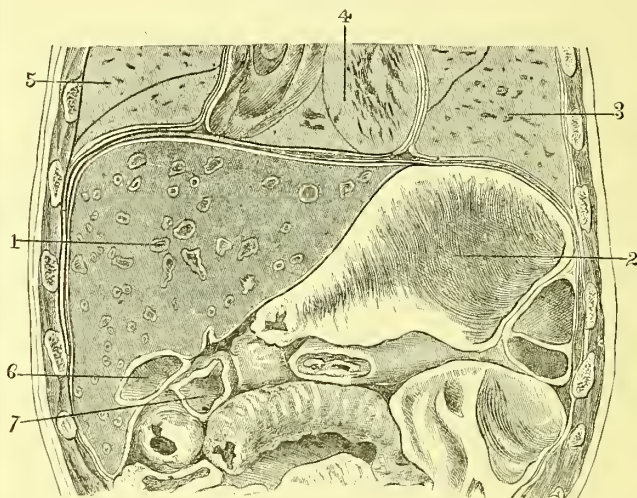
The Common Biliary Duct (ductus communis choledochus) is about three inches in length. It joins the duodenum at the middle of the vertical portion, about four inches from the stomach, penetrates the

Fig. 181.



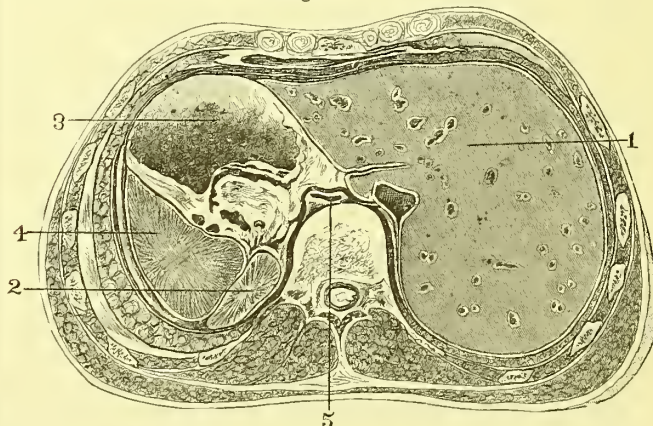
An antero-posterior (sagittal) section of the trunk in the median line. 1, the liver; 2, the stomach; 3, the heart; 4, one of the crura of the Diaphragm.

Fig. 182.



A transverse (frontal) section of the trunk. 1, the liver; 2, the stomach; 3, the lower lobe of left lung; 4, the heart; 5, the lower lobe of right lung; 6, the gall bladder; 7, the small intestine. The section of the largest tube to the left is the colon distended with flatus.

Fig. 183.

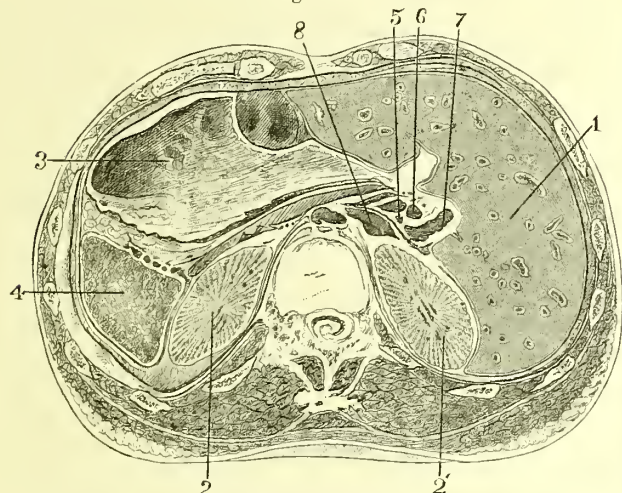


Horizontal section of the trunk at the level of the space between the ninth and tenth rib. 1, the liver; 2, the left kidney; 3, the stomach; 4, the spleen; 5, the œsophagus.

walls obliquely, and empties in the immediate neighborhood of the pancreatic duct. Its orifice is somewhat contracted just before entrance into the intestine.

Relations.—It lies in the gastro-hepatic omentum in front of the vena porta, below the hepatic artery; the right gastro-epiploica artery lies along its left side, together with lymphatic vessels and several lymphatic glands.

Fig. 184.



A horizontal section of the trunk at the level of the space between the twelfth dorsal and the first lumbar vertebra. 1, the liver; 2, the left kidney; 3, the stomach; 4, the spleen; 5, 6, section of the hepatic vessels; 7, the gall-bladder; 8, the inferior vena cava.

The following special study of the relations of the liver is based upon the investigations of Ludwig Mayer.¹

Additional Relations.—The liver is for the most part embraced in the dome of the Diaphragm, having indirect relations only with the base of the bony thorax. Its relations, in consequence of its bulk and irregular shape, can be studied to the best advantage by sections made in the most suggestive positions, viz.:

An antero-posterior section (sagittal section) through the mammary line.

An antero-posterior through the median line.

A (dextro-sinistral) transverse section (frontal section).

A horizontal section.

When an antero-posterior (sagittal) section of the trunk is made through the mammary line, about two and three-quarters of an inch (seven centimeters) from the sternum and downward to the hip-joint (Fig. 180), it is observed that the highest convexity of the liver is on a level with the fifth rib anteriorly and the eighth rib posteriorly, while it reaches three centimeters (one and three-sixteenths inches) above the last false rib. Its longitudinal diameter is nineteen centimeters (seven and one-half inches), and the transverse thirteen centimeters (five inches), as measured from the upper border of the right kidney. It lies in the vault of the Dia-

phragm, and reaches the posterior ends of the ribs. Anteriorly, the section reaches the abdominal wall and the four lower intercostal spaces and the corresponding ribs; posteriorly, it receives the right kidney (2) in a special depression; and interiorly lies a part of the omentum, beneath which is a portion of the ascending colon. (5) In young children the liver rises higher than it does in adults, and the lower margin descends below the costal arch in the right mammary line. In consequence of this, a small quantity of effused fluid in the right side of the pleural sac is more apt to escape notice, according to Eustace Smith,¹ the friction being often absent and the dulness attributed to the liver.

When an antero-posterior section is made in the median line (Fig. 181), the convex surface of the liver (1) is seen applied to the central tendon of the Diaphragm, and thus answering to that surface of the heart (3) which rests upon the Diaphragm, *i. e.*, to the left ventricle and the right auricle. The posterior border lies against the dorsal wall, or crura of the Diaphragm in the region of the ninth, tenth, and eleventh dorsal vertebrae. The concave under surface lies over the anterior superior surface of the stomach. (2)

Dr. A. von Brunn² has described as existing in the fœtus between the left lobe of the liver and the Diaphragm a bursa (*Bursa phrenico-hepaticus*) which appears to be connected with the original formation of the left lateral ligament.

When a transverse (dextro-sinistral frontal) perpendicular section is made (Fig. 182), the liver (1) is seen to lie at the plane of section opposite the seventh rib and to extend thence down to the twelfth. The section is of a triangular form, and occupies the angle defined by the thoracic wall, the heart, and the right lung. The left border goes slightly beyond the stomach, covering in the pyloric half of that organ, and the first portion of the duodenum. The outer right surface of the liver lies between the eighth and eleventh ribs and their intercostal muscles. If a needle is thrust between the seventh and eighth ribs, it will first traverse the pleural sac before entering the liver.

When a horizontal section is made between the ninth and tenth ribs (Fig. 183), the liver (1) is observed to be in close proximity to the right of the first lumbar vertebra.

Between the quadrate lobe and the right lobe as it lies near the kidney the gall-bladder is seen. In front of the gall-bladder lie the obliquely cut hepatic vessels and the portal vein. Between the liver and the inferior cava is a portion of the lesser omental sac. A part of the anterior half of the renal sulcus of the liver, since it is free from peritoneum, is applied directly to the capsule of the kidney, while its posterior part is separated from the kidney by the peritoneum. This relation is of importance in studying the evacuation of hepatic abscess and lesions of the bloodvessels.

When a horizontal section is made between the twelfth

¹ Clin. Studies of Diseases of Children, Lond., 1876, 102.

² Zeit. für Anat. und Entwicklungsgeschichte, I. 3 and 4 Heft, Taf. vii.

¹ Die Wunden der Leber und Gallenblase, Munich, 1872.

dorsal and the first lumbar vertebra, the kidney is observed to lie to the median side of the liver as that organ is represented in the section. (Fig. 184.)

The relations of the liver are subject to manifold disturbances by the varying conditions of the abdominal organs and the *movements of respiration*. When the stomach is empty, the left edge of the liver inclines to the left side of the abdomen; when the stomach is distended, it pushes the liver somewhat upward. When the great and small intestines are empty, the liver descends in the abdomen; and when they are distended, it is pushed directly upward. In emphysema, and after tight-lacing, owing to the low position of the Diaphragm, the liver is usually low; and in phthisis, ascites, tympanites, abdominal tumor, and in the bed-ridden, in consequence of the high position of the Diaphragm, the liver is unusually high. Hence the position of the lower edge of the liver in the abdomen is not, in itself, a guide to the size of the liver.

During *inspiration*, or in emphysema, which may be roughly estimated as equivalent to an inspiratory displacement, the whole liver is lowered about one-and-a-half inch below the thoracic wall, and its convexity is flattened by the descent of the Diaphragm. An additional quantity of blood is thereby pressed into the right auricle at the very time that the lungs as well as the heart, owing to the expansion of the chest, are capable of holding more blood.

During *expiration*, on the other hand, the chest is contracted, and the right cavities being compressed, the blood accumulates in the liver and the veins of the neck. In expiration the thin edge of the liver usually appears for about a finger's width just below the xiphoid cartilage, and above the stomach and colon. In deep inspiration the liver descends toward the umbilicus, stretches across the epigastrium, between the left and right seventh and eighth costal cartilages, and forms an elastic rounded prominence, dull on percussion. As a general result, the liver, during a deep inspiration, is, according to Sibson,¹ compressed and shortened from above downward, widened from side to side, and lowered so that fully one-half of the organ is exposed below the ribs and cartilages, instead of being sheltered almost entirely within them.⁽¹⁾

As a rare lesion Delafield² has found the transverse colon to be fixed above the liver so as to push it backward, downward, and to the right.

It is apparent, however, that most of these motions pertain to the right lobe. The left lobe is more fixed. A wound of the left lobe is liable to be complicated with severe hemorrhage into the abdominal cavity, owing to the proximity of the coeliac axis and its branches, whereas in the right lobe the hemorrhage is more apt to be external, and is not necessarily copious; though the wounding of the gall-bladder may lead to the accumulation of enormous quantities of bile-stained fluid in the abdominal cavity.

The following paragraphs have been abridged from Murchison.

In percussion during life the upper margin of hepatic dulness may be said to be twofold, one boundary limiting the region where the organ is in close approximation to the walls of the chest, and where the dulness is absolute; the other corresponding to the extreme height of the liver, and including the space where it is overlapped by the thin layer of lung, and where the sound on percussion constitutes a transition from the hepatic dulness to the pulmonary resonance. It is the latter which is usually regarded as the true upper margin of the liver. There is a peculiarity in the upper margin of the hepatic dulness which is of some practical importance, namely, that it is not horizontal, but arched. Commencing posteriorly about the tenth or eleventh dorsal vertebra, it ascends gradually towards the axilla and the nipple, and then again descends slightly toward the median line in front.

In determining the upper margin of hepatic dulness, we must trust to percussion alone. In ordinary cases it is sufficient to note the upper limit in what is called the *right mammary line*, or a line descending perpendicularly from the right nipple. Here, in a healthy adult, the *true* upper margin of the liver is situated in the fifth intercostal space, or, in rare cases, behind the fifth rib or in the fourth intercostal space. In this line the liver is overlapped by lung to the extent of about one inch. But in all cases of suspected hepatic disease, the upper margin of hepatic dulness ought to be determined in its entire course. In the median line in front, it usually corresponds to the base of the ensiform cartilage, or rises slightly above this.

To the left of the median line it is difficult or impossible to define the upper limit of hepatic dulness from the lower boundary of the heart, the two being in apposition, but a line drawn from the upper margin of hepatic dulness in the median line to the apex of the heart will usually correspond to the line of separation. In the *right axillary line*, or a line falling perpendicularly from the centre of the axilla, the upper margin of hepatic dulness corresponds to the seventh intercostal space, or, more rarely, to the seventh rib. In the *right dorsal line*, or a line falling perpendicularly from the lower angle of the scapula (when the arm is dependent), it corresponds to the ninth intercostal space, or the ninth rib.

The lower margin of hepatic dulness may be determined by percussion, and often also by means of palpation. It is, however, as a rule, less easily defined than the upper margin, being often obscured by a distended condition of the stomach or intestines. Hence it is always most satisfactorily examined when the stomach is empty, and after the bowels have been freely moved. In the right mammary line, it usually corresponds with the margin of the costal arch, or is half an inch above or below this; in the right axillary line it corresponds to the tenth intercostal space; and in the right dorsal line to the twelfth rib, although here it is usually difficult to define it from the dulness of the kidney. In the epigastrium, the lower margin of the right and left lobes

¹ Medical Anatomy.

² Pathological Anatomy, 172.

usually descends two or three inches below the angle of junction of the last costal cartilage with the sternum.

The ordinary extent of hepatic dulness, in an adult of average size, is four inches in the right mammary line, four-and-a-half or five inches in the right axillary line, four inches in the right dorsal line, and three or four inches in the median line anteriorly.

The following table, from L. Mayer,¹ is designed to show the character of the lesions of internal organs accompanying gunshot and other wounds in the neighborhood of the liver. It is thought that from it some approximation of the degree and locality of an injury may be secured, the point of entrance, exit, or lodgment of a projectile being previously known. It is evident, from the conditions determining the relations and size of the liver, that nothing but an approximation can in *all* cases be premised. The table is based upon an elaborate series of experiments on the effects of gunshot wounds upon the cadaver.

Entrance of projectile in front and to the right side. Viscera wounded.

- | | | |
|---|---|-------------------------|
| 1. Entrance beneath right nipple; exit inferior end of 12th rib. | } | Lung and liver. |
| 2. Entrance at the 7th rib near outer end of the costal cartilage; exit a hand's-breadth to the right of the vertebral column. | | Liver. |
| 3. Entrance between the 7th and 8th ribs; exit behind corresponding to 11th rib. | } | Liver. |
| 4. Entrance between the 8th and 9th ribs 8 inches from the median line; exit between 11th and 12th left ribs $\frac{1}{2}$ inch from their articulations. | | Liver and left kidney. |
| 5. Entrance between the 8th and 9th ribs forward and somewhat laterally; exit on level with 11th right rib 4 inches from the vertebral column. | } | Liver and right lung. |
| 6. Entrance through the 9th rib backward on level with 1st lumbar vertebra. | | Liver and right kidney. |
| 7. Entrance neighborhood of 9th and 10th ribs $3\frac{1}{2}$ inches from ensiform cartilage; exit between 7th and 8th ribs near vertebral column. | } | Liver. |
| 8. Entrance between 10th and 11th ribs; exit behind, $1\frac{1}{2}$ inch from vertebral column. | | Liver and colon. |

Entrance of projectile in front and to the left side. Viscera wounded.

- | | | |
|--|---|---|
| 1. Entrance above and 2 inches to left of umbilicus. | } | Left and right lobes of liver.
Ball found lying in duodenum. |
|--|---|---|

Entrance of projectile in front and to the left side.

- | | | |
|--|---|---|
| 2. Entrance near præcordium. | } | Inferior border of right lung, Diaphragm, left lobe of liver, anterior and posterior wall of stomach. |
| 3. Entrance at epigastric region to the left side of the ensiform cartilage. | | Liver. |
| 4. Entrance behind the 7th and 8th ribs. | } | Lung, Diaphragm, spleen, and right lobe of liver. |
| 5. Entrance behind 5th and 6th ribs of left side to-ward right side. | | Liver. |

Entrance of projectile to right hypochondriac, epigastric, and umbilical regions. Viscera wounded.

- | | | |
|--|---|--|
| 1. Entrance 2 or 3 fingers'-breadth beneath the last right costal cartilage; exit backward between 10th and 11th ribs of right side. | } | Upper portion of liver. |
| 2. In right hypochondrium. | | Liver and Diaphragm. |
| 3. Entrance anterior and upper portions of the right hypochondrium; exit opposite. | } | Liver. |
| 4. Entrance at the right hypochondrium and the borders of the false ribs. | | Liver. |
| 5. Entrance at right hypochond. 5 in. from median line; exit over right ileum 2 inches from median line. | } | Liver. |
| 6. Entrance in right hypochondrium; exit near inferior angle of scapula | | Liver. |
| 7. Entrance under ensiform cartilage; exit to the left between 2d and 3d false ribs, near the vertebral column. | } | Liver, pancreas, spleen, Diaphragm, right ventricle, and vertebral column. |

Entrance of projectile from behind. Viscera wounded.

- | | | |
|---|---|--------|
| 1. Entrance on the level of the 8th rib a hand's-breadth from the vertebral column; exit in front of mammary line, fracturing 7th right rib. | } | Liver. |
| 2. Entrance between 8th and 9th ribs; exit between the 7th and 8th ribs $4\frac{1}{2}$ inches from the sternum. | | Liver. |
| 3. Entrance between 8th and 9th right ribs $2\frac{1}{2}$ inches from vertebral column; exit between the 7th and 8th right ribs $4\frac{1}{2}$ inches from the sternum. | } | Liver. |

¹ Loc. cit., p. 70 (see p. 365).

<i>Entrance of projectile from behind.</i>		<i>Viscera wounded.</i>
4. Entrance between the 9th and 10th right ribs; exit to right of ensiform cartilage.	}	Prolapsus of lung through wound; wound of liver.
5. Entrance 2 inches from vertebral column on right side on level with 12th dorsal vertebra; exit a short distance from the ensiform cartilage on the right at the lower border of the liver.		Right lobe of the liver.
6. Entrance 4 inches above crest of the ilium 6 inches from the vertebral column.	}	Liver.
7. Near lumbar vertebrae through the last inferior right rib.		Right kidney; ball lodged $\frac{1}{2}$ inch in liver.

<i>Penetrating wounds.</i>		<i>Viscera wounded.</i>
1. Bayonet wound under left false ribs perpendicular to gladiolus, 2 inches above hip; 1 in. wide; course obliquely upward and inward.	}	Colon, stomach, left lobe of liver, Diaphragm, right ventricle, and right lung.
2. 1 inch broad on left side of breast.		Left lobe of liver, and outer layer of stomach.
3. Knife-wound 1 inch long, $\frac{1}{2}$ wide, on left side of thorax.	}	Diaphragm, liver.
4. Sabre wound of left side 5 inches over the crest of ilium to the middle of the 3d false rib.		Right ventricle, Diaphragm, left lobe of liver, stomach, spleen, descending colon.
5. Wound between 7th and 8th ribs on right side obliquely downwards.	}	Diaphragm and liver.
6. Sword-wound on right side between 8th and 9th ribs.		Right lobe of liver, right lobe of lung, right supra-renal capsule and Diaphragm; liver.
7. Fencing-foil wound between 8th and 9th ribs, 3 to 4 lines wide.	}	Diaphragm and liver.
8. Transverse wound of right side between 9th and 10th ribs.		Liver and Diaphragm.
9. Bayonet wound between 10th and 11th ribs, right side.	}	Liver.
10. Sword-wound on antero-lateral surface of right hypochondrium two fingers'-breadth under false ribs.		Right lobe of the liver.
11. Knife wound of right side of abdomen, 3 inches long, $\frac{3}{4}$ in. wide	}	Liver.
12. 4 in. deep wound in the præcordium obliquely upwards.		Concave surface left lobe of liver.

Variations.—The left lobe of the liver may extend entirely across the abdomen (Gruber).

REMARKS.—The clinical applications of a knowledge of the anatomy of the liver are both numerous and important. They relate to the parenchyma and to the relations of the viscus.

The *parenchyma of the liver* in its manner of response to injury bears a close resemblance to that of the spleen.

The capsule may be intact in cases where the parenchyma has been the seat of extensive laceration.¹ The liver is frequently contused in falls from lofty places, and as the result of such circumstances has been found torn in half without any lesion of the skin over the organ.²

The clinical study of the *relations of the liver* can be embraced under the following heads: (*a*) to the Diaphragm; (*b*) to the peritoneum; (*c*) to the stomach, colon, and duodenum; (*d*) to the pericardium and the heart; (*e*) to the bloodvessels; (*f*) to the biliary ducts and to the gall-bladder; (*g*) to the structures about the left lobe.

(*a*) Hydatids or abscess of the liver may discharge through the Diaphragm into the right pleural cavity. Out of 189 cases of hepatic hydatid, 81 had so discharged (Frerichs), and out of 300 cases of hepatic abscess reported by Waring 42 opened into the thoracic cavity.³

When adhesions have involved the base of the lung the hydatid mass or the pus may be discharged by the bronchial tubes. Fatal pleurisy may result from the upward pressure of a hydatid tumor of the liver without perforation of the Diaphragm.⁴

The connective-tissue interval between the liver and the Diaphragm may be the seat of an abscess, as recorded by Bright.⁵

From its relation to the abdominal parietes the liver—being forced in inspiration from above downward—is liable to compression, which indirectly aids in hepatic circulation. More particularly such compression will assist in forcing blood from the capillaries into the radicals of the hepatic vein. J. Hilton⁶ infers that the hepatic congestion which is apt to follow enforced rest in bed in individuals who have previously led active lives is due to the sudden withdrawal of this abdominal and diaphragmatic pressure.

¹ Pollock, Holmes's Sys. of Surg., iii. 416.

² L. S. Smith, Lancet, 1861, 208.

³ Murchison, 175.

⁴ Ibid. 63.

⁵ Clinical Memoirs on Abdominal Tumors, Syd. Soc. ed., 257.

⁶ On Rest and Pain, 231, 1877.

(b) The *peritoneum* is frequently involved in hepatic disease. Hydatid tumors often terminate fatally by rupture into the abdominal cavity. It is estimated by Waring that out of every three hundred cases of hepatic abscess fifteen will involve the peritoneum.

R. S. Orr,¹ in a case of hepatic abscess, found the pus in the gastro-hepatic omentum and about the duodenum and the pancreas.

(c) The *stomach*, the *colon*, and the *duodenum* are, from their extensive contact with the under surface of the liver, presumably liable to inflammatory involvement and afford probable points of outlet of fluid. Davaine has collected eleven cases, of which six were fatal, where hydatid tumor of the liver appeared to open into the stomach; and fifteen, of which only one was fatal, where there was reason to believe that it had opened into the intestine.²

The small intestine rarely enters into relationship with the liver. Bright³ found not only the colon and omentum but the small intestine lying in front of the liver, at the same time being pressed against it so as to make deep impressions upon its anterior surface. In such a case it can be seen how pus might readily pass from the liver into the small intestine and colon, or how readily the contiguous structures could be wounded by a single missile. W. Warren⁴ records a case of a needle-perforation of the walls of the stomach involving the liver in a child of eleven years. Intestinal hemorrhage and peritoneal adhesions between the organs ensued.

(d) The left lobe of the liver is less liable to interference than the other portions of the organ—a circumstance due to the diminished mobility of this lobe, and to the fact that it is in great measure removed from the causes of abscess and hydatid tumor. The most important clinical relation of the left lobe is with the pericardium.

The relations of the left lobe.—The left lobe of the liver enters into relations which in a clinical sense can be considered separately from those of the other lobes. The two divisions of the liver are drained by distinct sets of lymphatics. Malignant tumors may be confined to the left lobe, which, under these circumstances, may be confounded with enlarged conditions of the spleen.

Murchison⁵ refers to three cases only in which the pericardium was penetrated by an hepatic hydatid. All proved fatal either instantaneously by embarrass-

ment of the heart's action, or within a few hours by acute pericarditis. Mr. Bentley¹ narrates a case of hepatic abscess opening into the pericardium. A male, 29 years of age, was seized suddenly with pain to the right of the xiphoid cartilage, accompanied with dyspnoea and followed by cough and expectoration. Eight months afterward the patient was attacked with nausea, and pain in the præcordium. Death took place a few hours thereafter. At the autopsy it was found that the left lobe of the liver was occupied almost entirely by an abscess. The liver was greatly enlarged and adherent to the Diaphragm. The abscess communicated with the pericardium by a nipple-shaped opening.

The relations of the liver with the foramen of Winslow.—In examination of the abdomen after death in obscure morbid conditions, it is well to observe the appearance of the foramen of Winslow. Serving as it does to connect the greater with the lesser peritoneal chamber, this opening has been known to be a thoroughfare for fluids and growths of different kinds, by which they can pass from one peritoneal sub-chamber to the other. Thus, an hydatid cyst which originates in the liver has been detected projecting through the enlarged foramen.

The parietal relations of the liver.—The parietal relations of the liver are not important from an anatomical point of view, since any protrusion from the liver in this direction is at once recognizable by palpation. It is, all things considered, a rare circumstance for collections of fluid or tumors to project toward the periphery, because of the firm resistance interposed by the Diaphragm, the ribs, and the Inter-costal muscles.

(e) Instances of hepatic abscess opening into the inferior vena cava, of involvement of the portal vein (Hyrtl) and of the hepatic vein from similar causes (Davaine), have been recorded.—The remains of the umbilical vein, passing from the liver to the umbilicus, have served to guide the flow of pus from an hepatic abscess to the umbilicus. If, therefore, pus be induced by pressure to flow from a patulous umbilicus, and a probe be introduced into a sinus which extends upward toward the liver, it is probable that there is a collection of pus in or about that organ.

In examination of the liver of emaciated subjects, the viscus is sometimes found lying against the inferior vena cava and retarding, if not preventing, the ascent of injecting fluid along this vessel. It is not known that any similar causes operate in exciting

¹ Glas. Med. Journ., 1862, x. 284.

² See Murchison, Diseases of the Liver, 66.

³ Guy's Hosp. Rep., 1840, 37.

⁴ Lancet, ii., 1868.

⁵ Loc. cit., 64.

¹ Tr. Path. Soc. Lond., ii. 70.

mechanical congestions of the cava during life.—In cirrhosis of the liver the portal and hepatic veins are both constricted.

(f) *The biliary ducts and the gall-bladder.*—The exposed position of the excretory apparatus of the liver from the transverse fissure to the duodenum renders it peculiarly liable to pressure from adjacent parts; and when it is remembered that none of the several structures in this apparatus present any resistance to such outward pressure, it is not remarkable that mechanical obstruction to the flow of bile is a frequent clinical phenomenon. It should be recalled that the common biliary duct is most liable to be subjected to such pressure, since it lies exposed upon the anterior surface of the gastro-hepatic omentum in front of the portal vein and under the hepatic artery. These parts are easily seen in dissection by elevating the liver and depressing the stomach and the transverse colon. When the organs are preserved *in situ*, the student must think of them as *relaxed*. In this condition an unusual degree of pressure maintained for some time will be required to induce mechanical obstruction. But, should correlated conditions be such that the common duct is made *tense* in the gastro-hepatic omentum, slight degrees of pressure, particularly if they are exerted from *in front*, will suffice to occlude the common biliary duct.

Sibson states that, in estimating the descent and advance of the liver, the spleen, and the pancreas, the ascent and advance of the lower sternal ribs and cartilages must be taken into account. While the latter ascend and advance about an inch, the former descend and advance nearly two inches. In relation to the ribs and cartilages, the liver moves downward about three inches, but forward scarcely one inch, since their elevation adds to the depression and their expansion lessens the protrusion of the liver. The inspiratory lowering of the liver is notably greater than that of the stomach and the spleen, owing to the great height to which the organ first named rises in the right side of the dome of the Diaphragm. It is evident that such descent will relax the common biliary duct, since the movements of the pancreas must be less than those of the liver, if, indeed, the former structure, held as it is to the fixed middle portion of the duodenum, can be said to have any true downward movement. It will follow that in expiration, when the liver ascends, the common duct will be tense. It will also follow, all things being equal, that obstruction from outward pressure will be more apt to occur as a complication

in conditions in which the liver is high up, as in the expiratory position, than in those conditions in which it is low down, as in the inspiratory position.

It is a reasonable inference that in spontaneous rupture of the common duct three inches from the duodenum, such as happened in a case recorded by McSwiney,¹ the lesion occurred in deep expiration or with the liver in the position corresponding thereto. In Clark's case² of traumatic rupture of the duct, the force exciting the injury was severe, viz., a crushing of the body between two wagons, as the duct, even when relaxed, will yield to extraordinary pressure. The liver suffered but slight laceration, which was confined to the under surface of the organ. The hepatic duct (*i. e.* the duct above the common biliary duct) may be ruptured from injury. Death ensues from escape of bile into the peritoneal cavity.—In a case reported by T. M. Drysdale,³ traumatic rupture of the biliary duct was followed by enormous distension of the abdomen with a bile-stained serum.

Enlargements of existing organs, or new growths, placed toward the median side of the liver, will by their advancement toward the right side push the liver in front of them and to the right. This will tend, conceding the fixed position of the middle portion of the duodenum, to be of constant value in producing tension of the common duct. On the other hand, protrusions of any kind behind the liver, by throwing it inward, will relax the duct.

A knuckle of large intestine may intrude itself between the Diaphragm and the liver.

Since the under surface of the liver is in contact with the pyloric end of the stomach, the transverse colon, and the first portion of the duodenum, the more obvious sources of visceral pressure against the liver will arise from them. The colon is especially apt to press against the common duct from two causes: first, from the lodgment of scybalous masses in the canal in persons of a constipated habit; and, secondly, from the enormous gaseous distension to which this portion of the large intestine is liable.—Pressure exerted from the stomach is frequently associated with cancer of the pylorus.

Among the sources of pressure which are capable of occluding the common duct, and which yet might not attract the attention of the student in examining the normal relations of the duct, are the following:—

Causes operating at the hepatic end of the duct.—Conspicuous among these are lymphatic glands in the

¹ Dublin Journal of Medicine, 1866, 518.

² Lancet, 1864.

³ Am. Journ. of Med. Sci., 1861, 99.

transverse fissure. These may be enlarged when the liver has undergone cancerous, amyloid, or tubercular change. Primary cancer of the stomach may induce infiltration in the lesser omentum, and by that means compression of the bile-duct.

Causes operating at the duodenal end of the duct.—Tumor of the pancreas may either invade the duodenum and close the orifice of the common duct, or penetrate and obstruct the duct at different parts of its course, but when large, it may compress the duct from without so as to constrict or obliterate its lumen.—Cicatricial compression or ulceration may involve the duodenal orifice.

Causes operating between the hepatic and duodenal terminal orifices.—Here may be mentioned enlargement (either cancerous or tubercular) of the retroperitoneal glands, or tumor of the omentum.

The common duct is capable of being dilated. Rokitsky gives an instance of a gall-stone the size of a hen's egg passing through the duct. The parts after such distension would naturally fail to regain their normal condition, and may permit regurgitation of fluid, as well as exit of distomata (flukes) and of hydatids from the liver to the duodenum.

Both the hepatic duct and the common biliary duct may become enormously dilated above a point of compression.¹

The *gall-bladder* normally presents clinical relations which may be considered as of two kinds, visceral and parietal.

The *visceral* relations are with the transverse colon and the upper part of the second portion of the duodenum, answering to the point where these structures come in contact with the under surface of the gall-bladder. Frequent variations in their relative positions, however, are noticeable, and it should not be forgotten that the gall-bladder may be in contact with the first portion of the duodenum instead of the second, and in some instances with the pylorus. So the fundus may lie upon the ascending instead of upon the transverse colon, and even upon the right kidney. In instances in which the liver is pressed downward, the relations of all its parts are violently disturbed. In such cases the gall-bladder lies in contact with the small intestine.

Gall-stones are in the vast majority of cases lodged at the fundus of the gall-bladder. At the same time it must be borne in mind that any portion of the biliary apparatus may accommodate them. Thus

they may be impacted in the neck of the cystic duct; they may form in the radicles of the hepatic duct in the interior of the liver; they may be lodged in the hepatic duct before its junction with the cystic duct; or they may be lodged in the common duct.

Perforation of the walls of the gall-bladder by a gall-stone need not necessarily lead to the lodgment of the concretion in the abdominal cavity. During its slow exit, sufficient inflammation may be excited to cause adhesion between the viscus and adjacent parts, and thereby to determine the appearance of the stone in any of the situations enumerated below.

It is theoretically possible for a gall-stone to enter *any* portion of the intestinal canal below the Diaphragm, as well as the renal pelvis and ureters.

Instances have been recorded of the escape of gall-stones into the colon, duodenum,¹ stomach, portal vein, pleural cavity, pelvis of kidney, and even vagina. In some rare cases in which it had been supposed, from stones having been vomited, that the perforation had occurred through the walls of the stomach, it was found after death that it had taken place through the walls of the duodenum.

The colon, notwithstanding its proximity to the gall-bladder, is infrequently selected for the exit of a gall-stone—a fact probably due to the extreme mobility of this portion of the alimentary canal. Out of seven of the recorded instances of such lesions six were due to cancerous ulceration.²

The *parietal* relations of the gall-bladder pertain entirely to the fundus. This commonly lies in contact with the abdominal wall, directly to the outer side of the Rectus Abdominis muscle. In enlarged conditions of the gall-bladder the fundus can be detected through the skin. Any fluctuating tumor in this position should be punctured with extreme caution. According to Hyrtl, J. L. Pettit opened such a collection in mistake for an hepatic abscess. Pagenstecher³ describes a curious case in which laparotomy had been performed for the relief of intestinal obstruction. The gall-bladder was found adherent by its fundus to the abdominal wall near the right iliac fossa, while higher up, between the remainder of the viscus and the abdominal wall, coils of small intes-

¹ According to C. Murchison, *Diseases of the Liver and Gall-Bladder*, 515, "the opening in the biliary passage is almost always at the fundus of the gall-bladder, but occasionally it is in the common bile-duct; that in the duodenum is in its third or lowest division."

² *Ibid.*, p. 516.

³ Langenbeck's *Archiv für Klin. Chirurgie*, 1861, ii.

¹ Todd, *Dublin Hosp. Rep.*, i.

tine were found compressed at the operation. These coils were released, and the gall-bladder was secured to the parietes and opened, a proceeding which was followed by the flow of a large quantity of bile. The patient, although an old man of seventy years, recovered.—When gall-stones escape through the integument, of which 70 cases are now recorded,¹ the opening, as one would expect, is opposite the fundus. —When the gall-bladder enlarges, it may be brought in contact with the suspensory ligament, as the latter structure passes from the anterior wall of the abdomen to the liver. The peculiar origin of the suspensory ligament should not be forgotten. In some cases, a gall-stone escaping from the gall-bladder, which has previously secured adhesions to the abdominal wall, may not escape directly through the parietes, but be lodged in the suspensory ligament and be guided by it to the umbilicus. In extremely rare cases the gall-stone may descend between the muscles of the abdomen, or between them and the peritoneum to the pudenda. A calculus under these circumstances has been extracted from the submucous tissue immediately above the clitoris.² Such eccentric dispositions are more apt to occur when the calculus has been brought down to the umbilicus, but cannot escape thence, and is led by gravity to descend to the pubis in the wall of the abdomen, to the groin,³ or even to the iliac fossa or the buttock. D. Hayes Agnew has found the last a site for the deposition of gall-stones. In this case, a female, fifty-eight years of age, had had an enormous cyst over the right buttock, measuring eighteen inches in either diameter. In removing the sac it was found that it led up to the crest of the ilium, and turned inward, following the curve of the iliac fossa. At the bottom of this pelvic prolongation of the sac, a nest of biliary calculi about the size of hickory-nuts was found. The previous medical history was sufficient in the judgment of Prof. Agnew to indicate that a displaced and enlarged liver had brought the gall-bladder in contact with the iliac fascia, with a subsequent escape of the gall-stones between the fascia and the Iliacus Internus muscle—the cyst in the buttock being an adventitious formation in connection therewith. —These special forms of the lesions created by gall-stones are almost peculiar to females.

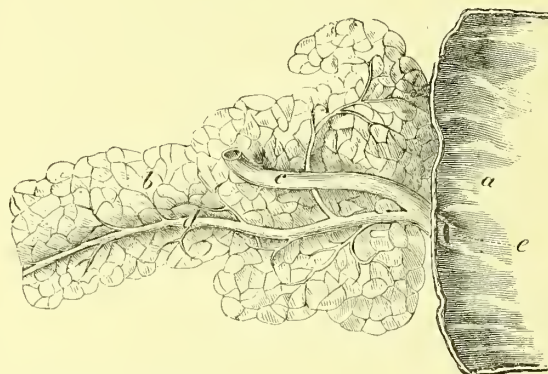
THE PANCREAS.

The Pancreas (fig. 4, Plate CII.) is the largest racemose gland in the body. It is an appendage to the

alimentary canal at the duodenum, and lies within the right hypochondriac, the epigastric, and the left hypochondriac regions. Long and slender, with a doubling and thickening at one end, its general form has been compared to that of a hammer; the main portion, corresponding to the “handle” of such an instrument, is called the “body;” the free portion, the “tail;” while the “hammer” proper is called the “head” of the organ.

The head (duodenal portion, vertical portion) is nearly quadrilateral in form; it lies within the median or concave border of the duodenum, to which it

Fig. 185.



The duodenum opened showing the valvula conniventes, and the opening of the common bile-duct. The duct of the pancreas is also represented in greater part of its course. *a*, duodenum. *b*, pancreas. *c*, common bile-duct. *d*, pancreatic duct. *e*, opening of the common duct in the intestine.

accurately conforms, and slightly overlaps the anterior and the posterior surfaces. The body is of a more or less prismatic form, slightly twisted upon itself; the upper, thicker border is grooved for the splenic artery and vein. The tail is thin and tapering, and is directed toward the spleen. The body and the tail are continuous, and in reality form the *horizontal portion* of the gland, while the head is quite distinct and forms the *vertical portion*. The position of the portal vein and the superior mesenteric artery and vein serves to limit these two portions.

The pancreas measures six to eight inches in length, one-and-a-half inch in breadth, one half to one inch in thickness, and weighs from two and a half to four and a half ounces. Its texture is somewhat looser than that of the salivary glands, but is at times, particularly in thin persons, of a peculiar density.

Extending throughout its entire length, concealed within the substance of the gland, but lying nearer the lower border, is the excretory duct.

The excretory duct (duct of Wirsung) usually joins the common bile-duct, and empties into the duodenum with the latter. The manner of termination of the

¹ Murchison, l. c., 521.

² Gaz. des Hôp., Oct. 8, 1846.

³ Murchison, 522.

pancreatic duct has been the cause of much discussion. The following arrangement of parts may be considered the average one: Both the pancreatic duct and the common bile-duct joining at an acute angle present their terminal orifices within a little chamber or cloaca (ampulla of Vater), lined with mucous membrane, and terminated by a teat-like contraction within the duodenum. In its absence, which is unusual, the pancreatic duct empties into the duodenum, while the common bile-duct finds a separate outlet by its side.

An accessory duct (duct of Santorini, azygos canal) from the lower portion of the head of the gland often opens by a separate opening into the duodenum. It anastomoses with the main duct so that a stream of water thrown into the main duct from the duodenum will in part escape by the mouth of the accessory duct.

Relations.—The pancreas, like a salivary gland, adapts itself to the inequalities of the region it occupies. The vertical portion, as already noted, is fixed to the nearly immovable middle third of the duodenum, where it is in close relation to the mesentery. The horizontal portion of the organ is more movable, and is said to “float.” Owing to the disposition of the splenic vein, this portion follows to a slight degree the motions of the spleen, the stomach, and the Diaphragm. The tail thus tends to lie a little above the horizontal line, and the “head” a little below. The entire organ is slightly arched, the convexity being directed in front.

The pancreas lies opposite to the twelfth dorsal vertebra, although it may be found as low down as the second lumbar, or as high up as the eleventh dorsal. In emaciated individuals the pancreas can be readily outlined by palpation, and care should be taken not to confound the healthy organs thus determined with abdominal tumor.¹ The posterior wall of the omental sac alone intervenes between the pancreas and the anterior abdominal wall when the stomach is depressed, as in prolonged fasting. In repletion the stomach lies directly in front of the organ. Behind it are the aorta, pillars of the Diaphragm, thoracic duct, vertebral column, kidneys, and the supra-renal capsules. The lobus Spigelii and the inferior vena cava lie behind the head. As already seen, the middle portion of the duodenum lies to the right side, and the spleen to the left. The horizontal portion is grooved above by the splenic vein, and posteriorly from below upward by the portal vein and the superior mesenteric artery.

A. Cooper² found, after the ligation of the thoracic duct in dogs, that the pancreas was forced forward. It is probable that a similar change in position may ensue in the human subject after obstruction in the abdominal portion of the thoracic duct.

Bloodvessels.—The arteries of the pancreas are numerous minute branches derived from the splenic, as well as from the superior pancreato-duodenal, the inferior pancreato-duodenal, and the superior mesenteric arteries. The gland is grooved posteriorly by the superior mesenteric artery; the artery may perforate the gland structure much after the plan by which the internal maxillary artery perforates the parotid gland. The *venous blood* returns by the splenic and superior mesenteric veins. In enlarged conditions of the pancreas both the arteries and the veins may be compressed.

Nerves.—The nerves are derived from the branches of the coeliac axis.

Lymphatics.—The lymphatics terminate in the lumbar vessels and glands.

Variations.—The horizontal portion may be sigmoid instead of straight. The vertical portion is bulkier in the adult than in the young individual, and embraces to a greater degree the duodenum. The splenic vein may infrequently follow the inferior border of the horizontal portion instead of the superior. The groove for the mesenteric vessels may be converted into a canal.—The head of the gland is often separated from the body by a deep fissure. In the instances in which the pancreas is completely divided at this point the head has received the name of the *lesser pancreas*. Under these conditions a distinct duct is seen ascending and commonly joining the main duct near its termination.—The common bile-duct lies either within a complete canal of pancreatic tissue, or at least in a deep notch in the posterior part of the head of the pancreas.¹

REMARKS.—The clinical study of the pancreas embraces the relations borne by the gland to the other organs of the epigastric and hypochondriac regions and to the peritoneum. At the risk of repeating the relations above cited, it may here be said that the pancreas from its position across the abdomen involves by its right extremity the liver, and is in clinical relation with the ascending portion of the duodenum; by its middle portion with the superior mesenteric artery and vein, and the greater part of the stomach, the aorta, and the thoracic duct; and by its left portion with the spleen. The peritoneum is more intimately associated with the pancreas at its right extremity than with either the left extremity or with the middle portion.

The relations of the pancreas can be recalled to advantage in studying many of its morbid states. A

¹ Med. Times and Gaz., 1869, Jan. 16.

² Med. Rec. and Repository, 1798, 86.

¹ A. Verneuil, Comptes Rendus des Séances et Mem. de la Soc. de Biologie, 1852, iii. 136.

tumor directly above the stomach at the epigastrium may be a cancer of the pancreas, which has forced the stomach downward. The stomach may be adherent to the pancreas, or the latter may even fill up an opening in its walls. The head of the pancreas in diseased conditions may so compress the common bile-duct as to induce icterus, and, by obstruction of the pancreatic duct, cause derangement of the proper pancreatic secretion.

When a morbid growth involves the common duct of the pancreas, the tributaries of the duct behind the point of obstruction rarely become sufficiently dilated to attract attention. In a case narrated by J. S. Bristowe, it was found that obstruction of the common bile-duct, which was distended to the size of the duodenum, was associated with enlargement of the pancreas. The pancreatic duct was dilated to a remarkable degree. The main portion pursued a tortuous course the entire length of the gland, and exhibited a diameter large enough to admit the tip of the little finger. The lower ends of the hepatic and pancreatic ducts were involved in a mass which was probably inflammatory.—In another instance recorded by the same writer, a cyst holding from two to three ounces of a colorless transparent fluid was found lodged in the small omentum, and was regarded as a result of pancreatic obstruction.¹

The head of the pancreas may by enlargement compress the duodenum,² and the aorta. Enlarged conditions of the pancreas may compress the lacteals, or may in turn be displaced forward by the distension of the thoracic duct *supra* or by the enlarged retro-peritoneal lymphatic glands.³

Cancerous growths, by increasing the size of the pancreatic mass, may cause it to assume relations not entertained in a normal condition. Among the parts so related may be mentioned the colon at the hepatic flexure, the liver, and the structures at its transverse fissure. The diseased mass may embrace the duodenum, press on the pylorus, or rarely surround the lesser curvature of the stomach. The exemption of the spleen, supra-renal capsules, and the kidneys from these encroachments is very striking.—The pancreas putrefies readily.

THE PERITONEUM.

The Peritoneum (fig. 1, Plate C.) is the serous membrane which lines the abdominal cavity. It aids

in supporting the abdominal viscera, defines the pelvic contents superiorly by the secretion of serum, facilitates the motions of the organs among themselves, and aids in maintaining the patulency of the alimentary canal and various gland-ducts.

The most extensive of serous surfaces, it differs from others of its class in possessing in the female two openings of communication with mucous membrane, viz., those of the Fallopian tubes, through their free extremities.

The inner surface of the peritoneum is smooth and covered with flattened, tessellated epithelium; the outer is rough and is in relation with connective tissue.

The cavity defined by the peritoneum is called the *peritoneal cavity*, and is divided into the greater and lesser cavities, as will be described further on.

The peritoneum as it lines the walls of the abdomen is called the *parietal* portion, and where it is in contact with the abdominal contents it is called the *visceral* portion. A viscus (as, for instance, the pancreas) lying close to the posterior wall of the abdomen may receive but a small surface of contact, when it is said to be imperfectly invested by peritoneum; but when the organ lies further forward, the surrounding peritoneum is said to invest it completely. In an exact sense the peritoneum, however, in no case completely embraces any organ, an appreciable interval existing between the sides of the loop permitting arteries to enter, and veins and lymphatics to escape. Fat is very liable to accumulate in such localities. When this becomes abundant and the colon is contracted, the operation of colotomy becomes very difficult to perform.¹

The *sub-peritoneal* connective tissue in the posterior and lower portion of the abdomen is exceedingly loose and abundant; but is compact in the anterior and diaphragmatic walls, and as a rule is sparse and firmly united to the intestine. It is continuous above with the subpleural connective tissue, through the œsophageal and aortic openings in the Diaphragm, and below with the pelvic connective tissue and fasciæ. It also escapes from the crural canal and joins the connective tissue of the thigh.

Beginning the description at the umbilicus, it is found that the peritoneum passes from that point to the Diaphragm, from which it is reflected to the upper surface of the liver, where it assists in forming the lateral ligaments. The remains of the umbilical vein are in this region held within a fold of peritoneum,

¹ St. Thom. Hosp. Rep., 1873, 141.

² Fletcher, Birmingham Path. Soc.; Prov. Med. Journ., 1844.

³ Bright, Med.-Chir. Trans., 1833, xviii.

¹ Curling, Diseases of the Rectum, 4th ed., 180.

which has received the name of the *suspensory* or *longitudinal ligament*. This structure is of a triangular shape, its apex being below at the umbilicus, and its base above at the upper surface of the liver, where it serves to limit the right and left lobes. Passing from the upper to the under surface of the liver the membrane covers in the gall-bladder, and, reaching the transverse fissure, it is deflected downward and to the left upon the stomach, forming the *anterior layer* of the *gastro-hepatic omentum*.

Reaching the stomach the membrane passes over its anterior aspect, embracing at the same time the spleen. Between the stomach and the spleen a short but stout duplicature has received the name of the *gastro-splenic omentum*. It carries the vasa brevia and the splenic vein.

From the stomach it passes to the great omentum, the outer surface of which it defines, and is carried upon the posterior surface of the omentum upward toward the transverse colon, and thence above this portion of the intestine back to the vertebral column.

The *great omentum* is a large apron-like structure commonly loaded with fat, extending along the greater curvature of the stomach, and descending in front of the intestine. On the right side the base is continuous with the *hepatico-colic ligament*, where a fold is seen. The lower free margin of the omentum tends to be slightly prolonged. Hernial protrusions containing omentum are more common on the left side.

The peritoneum thence passes down in front of the duodenum, the aorta, and vena cava, to be again projected to form a loop of great extent embracing the jejunum and ileum, and is known as the *mesentery*. The *mesentery* is at its root about six inches in length, and is directed obliquely downward and to the right from the second lumbar vertebra to the right sacro-iliac junction. Owing to this circumstance, the mass of small intestine inclines to the right side, and is thus a more frequent ingredient of right inguinal hernia than is the left. In placing the pad of a truss adapted to the right side of the groin it is recommended to turn the patient upon the left side with the object of relieving the right inguinal canal from the pressure of the intestinal mass.

The cæcum and vermiform appendix are next invested by the peritoneum, which then covers the anterior two-thirds or five-sixths of both the ascending colon and the descending colon, and defines a short and in some respects imperfect ascending and descending meso-colon.

From the vertebral column the peritoneum is projected to form a loop sustaining the transverse colon,

which loop has received from this relation the name of the *transverse meso-colon*. This structure lies beneath and in close relation with the posterior layer of the great omentum. Formerly the omentum was described as inclosing the transverse colon.

From the sigmoid flexure the peritoneum passes to the upper portion of the rectum, behind which is a small fold, the *meso-rectum*. The membrane, however, soon leaves the rectum, first at the sides, and finally in front, so that the greater portion of the gut is without peritoneal covering.

The pelvic layer of the peritoneum in the male exhibits two folds extending from the rectum to the bladder. These are called the *recto-vesical folds* (plicæ semilunares), and define laterally the *recto-vesical fossa*.

In the female the above folds are absent. The bladder and uterus are, however, connected by a pair of lateral folds, the *vesico-uterine* folds, while the *uterus* and *rectum* are joined by an analogous pair called the *recto-uterine* (utero-sacral) folds. The peritoneum is in contact with a small portion only of the posterior wall of the vagina. In addition to these the body of the uterus is embraced by the *broad ligaments* at the same time that the ovaries and Fallopian tubes are held laterally by the *infundibulo-pelvic ligaments*.

The pelvic layer, after covering the summit of the bladder, passes to the anterior wall of the abdomen. At the inguinal region it presents two shallow pits or fossæ (Fovæ inguinales). The internal of these answers in position to the external abdominal ring; the external to the internal abdominal ring. The latter is the seat of the foetal prolongation carrying the testis in its descent from the abdomen to the scrotum in the male. In the female the internal abdominal ring accommodates the canal of Nuck.

Extending from the sides of the bladder upward along the abdominal wall to the umbilicus is a pair of cord-like bands answering in position to the hypogastric arteries of the foetus. They are in consequence known as the *remains of the hypogastric arteries*. Extending vertically upward from the summit of the bladder to the umbilicus is a somewhat similar cord which answers to the *remains of the urachus*.

The deep epigastric artery of either side, as it passes upward between the inguinal fossæ, creates a small peritoneal fold, the *plica epigastrica*.

Reviewing the description from its starting-point, viz., the umbilicus, it will be seen that a large cavity has been described (the greater peritoneal cavity), which does not cover the *posterior* wall of the stomach and adjacent surfaces. This second, smaller

cavity has received the name of the *lesser peritoneal cavity*, and will be now described.

In order properly to do this it is necessary to turn for a moment to the development of the parts. The stomach, as is the case with the other abdominal viscera, is received in a loop of peritoneum projected from the vertebral column. The pedicle of this loop has received in the fœtus the name of the *meso-gastrum*.¹

At the fourth or fifth week, when the *meso-gastrum* performs a duty analogous to the mesentery, the stomach is placed vertically in the abdomen. As the pyloric end is deflected to the left, the *meso-gastrum* gradually undergoes a great change. It is carried by the stomach from the posterior toward the anterior wall of the abdomen, and sags downward so as to hang in front of the intestine, and forms the *great omentum*.

It will be seen that a cavity, lined with peritoneum—the lesser cavity of the peritoneum²—lies between the stomach and the vertebral column. It is continuous with the interior of the great omental loop below and extends along the gastro-hepatic omentum from its posterior layer to the lesser curvature of the stomach, and thence covers the posterior surface of this organ. From this point it passes within the great omentum, and forms its *inner* layer. Along the back of the lesser cavity it covers in the pancreas and portions of the spleen and the Diaphragm. It ascends upon the latter and is reflected thence upon the liver, and from this organ in turn to the posterior layer of the gastro-hepatic omentum. The lesser peritoneal cavity communicates with the greater peritoneal cavity by an opening between the stomach and the liver called the foramen of Winslow. The *foramen of Winslow* is an aperture bounded behind by the vena cava, in front by the hepatic vessels, above by the lobe of Spigelius as it joins with the caudate lobe, and below by the duodenum. It is probably originally created by the traction of the liver through its common bile-duct, at the time of the deflection of the stomach toward the right side. It generally measures an inch in diameter. This measurement is less when the stomach is distended.

The lesser cavity can be inflated in the infant. Later in life the great omentum becomes here and there perforated, when inflation is no longer possible.

Nevertheless, the cavity may be occupied by fluid in the

adult (forming the abnormal condition known as *Hydrops saccatus*) through occlusion of the foramen of Winslow.

Peritoneal folds. In consequence of the intricate arrangements obtained in applying a serous membrane to such varied surfaces as those of the abdominal cavity, a number of folds (ligaments, plicæ) are formed. Some of these have already been described. But to insure ease of reference the complete list is herewith given.

(1) The suspensory ligament of the liver, determined by the position of the umbilical vein.

(2) The right and left lateral ligaments of the liver.

(3) The gastro-splenic omentum, ligament, or fold.¹

(4) The gastro-phrenic ligament.

(5) The costo-phrenic fold. This originates from the Diaphragm opposite the tenth to the twelfth rib, passes to the splenic flexure of the colon, thence over the splenic flexure, and reaches the left kidney and the descending colon.

(6) The hepatico-renal fold.

(7) The recto-vesical, recto-uterine, vesico-uterine folds, and infundibulo-pelvic ligaments.

(8) The ileo-cæcal fold.

(9) The mesenterico-meso-colic fold. This is described as lying between the mesentery and the meso-colon of the sigmoid flexure. It would appear to limit the descent of the latter.²

Peritoneal Fossæ.—In addition to the above folds five fossæ (peritoneal pouches, peritoneal pits) have been described.

(1) *The duodeno-jejunal fossa*.—The duodeno-jejunal fossa (fossa duodenalis) lies to the left side of the third lumbar vertebra between the pancreas, the left kidney, and the aorta. It has the capacity of a walnut, and presents its orifice forward. The upper margin is lost in the lower leaf of the transverse meso-colon; it contains the inferior mesenteric vein. The lower is produced upon the peritoneal covering of the duodenum, and contains the left colic artery. The pouch is ordinarily occupied by the junction of the duodenum with the jejunum. (Luschka.) Treitz³ has described cases of hernia situated in this locality under the name of *hernia retro-peritonæalis, i. e.*, hernia into the retro-peritoneal space. Montard⁴ gives a case of congenital retro-peritoneal sac. At the autopsy a bladder-like mass, of the size of a child's head, was seen at the back part of the abdomen, covered with a thin, smooth, and perfectly transparent coat, presenting all the appearances of the peritoneum. It was found when opened to contain a knuckle of the small intestine. The foramen of Winslow was absent, and the stomach was in its primitive fœtal position. The

¹ See, in connection with this subject, The Peritoneal Covering of the Spleen and the Lig. Pleuro-colicum. (Archiv für Anat. und Phys., etc., 1867, 565, Taf. xvii. A.)

² Gruber, Zeitschrift der k. k. Gesellschaft der Aertze zu Wien. Vierter Jahrg. Bd. ii., 432.

³ Ein Beitrag zur Geschichte inner. Hernien.

⁴ Union Médicale, No. 93, 1869, cited in N. Y. Med. Journ., xii. 230.

¹ J. Müller, Meckel's Archiv, 1830, 411, Taf. xi., figs. 1–10.

² See the dark-shaded space in fig. 1, Plate C.

patient did not exhibit at any time symptoms of intestinal obstruction. The cause of death was typhoid fever.¹

(2) *The sub-cæcal fossa*.—The sub-cæcal fossa is a pocket situated behind and below the cæcum. Very often it is but a shallow depression, but it may be as long as one's fingers, when it is directed upward between the layers of the meso-colon. It is stated by Luschka that hernia may be situated at this position.

(3) *The ileo-cæcal fossa*.—The ileo-cæcal fossa lies between the opposed sides of the cæcum and the end of the ileum.

Its size is variable, but generally is that of the thumbnail.²

It was reserved for Schott³ to direct attention to the fact that this pouch is sometimes the seat of a cystic growth, which, by pressure upward, may occlude the ileo-cæcal aperture, and induce fatal intestinal obstruction.

(4) *The inter-sigmoid fossa*.—This is the name given by Luschka to the small pouch developed from the left leaf of the meso-colon of the sigmoid flexure. It is inconstant and of variable size. It appears to be the least important of the peritoneal fossæ.

(5) *The recto-vesical fossa* lies between the rectum and the bladder in the male. It is about four inches above the anus.

Variations.—*The meso-rectal fold*.—The mass forming the body of a prolapsed rectum is often tilted forward or to one side, and the intestinal aperture assumes the form of a

fissure, receding from the surface of the tumor, owing to the traction exerted upon it by the meso-rectum.

A congenitally misplaced kidney may have a distinct meso-nephron.¹

An anomaly, recalling the period in fetal life at which the small and large intestines are arranged near the median line, has been recorded by Gruber,² in which the large and small intestines of an adult were held in complete connection by a common mesentery.

Appended to the peritoneum here and there are pedunculated tags or pouches of peritoneum containing fat. These are called *appendiculæ epiploicæ*, and though common along the course of the transverse colon, are of unknown function.

The attachments of the peritoneum which have clinical significance.—The degree of firmness of attachment of the peritoneum to the different organs varies. The membrane is loosely attached to the organs in the retro-peritoneal space, but firmly to the intestines. It is capable of undergoing marked changes of relation. Thus the gravid uterus, ovarian tumors, and hernial protrusions will appropriate peritoneum from adjacent points,—the uterus and ovaries from the broad ligaments and their related folds; the hernial sacs from the inguinal fossæ and bladder. The degree of this appropriation depends, it would seem probable, upon the rate of growth in the mass. Thus a rapidly growing tumor, or rapidly distending viscus, will adapt to itself the loose membrane from adjacent parts.

When the growth or viscus increases in size slowly, the peritoneum may grow *pari passu* with the other elements of new structure. In a greatly distended urinary bladder the fundus may reach to within one inch and a half of the ensiform cartilage. The reflexion of the peritoneum from the fundus to the abdominal wall in such a case would be within an inch of the umbilicus.

In rupture of the uterus the peritoneum will frequently resist the direct effects of the lesion; and hemorrhage into the peritoneal cavity need not result from this accident.

In the operation of ovariectomy the peritoneum may be easily stripped from the ovarian cysts when these growths have simply appropriated as coverings

¹ For other cases with figures see Trans. Path. Soc. Lond., 1865, 139; and Peacock, *ibid.*, ii. 60.

According to R. J. Anderson, the fossa duodenalis is limited above by the posterior layer of the transverse meso-colon, internally (medianly) by the duodenum, and bounded at the left by a sharp falciform marginal fold. The aorta lies medianly and behind. It may have an extent of two inches from above downward, and an inch in depth. In the fold mentioned the left colic artery may be found, and according to some writers the inferior mesenteric vein. The vein last mentioned may also be crossed by this artery below the fold. From one to two inches of intestine lie within the fossa.

The fossa is caused (in the language of the same writer) as follows: "At a time when the liver is large and occupies both hypochondria, the alimentary canal is mesial (*i. e.* in the middle line). When the liver becomes smaller (relatively), and comes to occupy the right hypochondrium, the pyloric end of the stomach and the duodenum are drawn to the right, the upper and lower transverse parts of the duodenum being thus produced. The peritoneum in the neighborhood of the duodeno-jejunal flexure is also drawn to the right side; and in this way, in consequence of the loose tissue beneath the posterior abdominal peritoneum in that situation, the fossa and the plica duodeno-jejunalis are produced. The movement of the colon does not compensate for the movement of the duodenum, but rather tends to throw into relief the prominent border of the fold."—Journ. Anat. and Phys. 1878, 237.

² Luschka, Ueber die peritoneale Umlüftung des Blinddarmes und über die Fossa ileo-cæcalis, Virchow's Archiv, vol. xxi., 1861, 285, Taf. iv. f. 3.

³ Beiträge zur Anatomie der Fossa ileo-cæcalis, Wochenblatt der Zeitschrift der k. k. Gesellschaft der Aertze in Wien, 1862, No. 44.

¹ A. E. Durham, Guy's Hosp. Rep., iv. 1860, 420.

² Beiträge zur den Bildungshemmungen der Mesenterien; Archiv f. Anat. Phys. und Wissenschaft. Med., 1862, 588, Taf. xv. fig. 1, 2. See, also, on the presence of a common mesentery for the jejunum and ileum, and the initial half of the large intestine, accompanied with lateral transposition of the viscera, Ueber das Vorkommen eines Mesenterium commune für das Jejunum-ileum und grossere Anfangshälfte des Dickdarms, etc. *Ibid.*, xiv. 1865, 558.

the adjacent loose folds extending from them to the pelvis; while, on the other hand, the firmer union existing between the peritoneum and the anterior abdominal wall renders it difficult under certain conditions to distinguish the membrane from the firm sub-peritoneal fibrous layers. It is recommended by W. Atlee, of Philadelphia, under such circumstances to insert the hand in the wound, and pass it upward to the region of the umbilicus. If the membrane in question be peritoneum, it will of course be free at the position of the umbilical cicatrix, while, if it be a part of the abdominal wall, it will be attached there.

The Retro-Peritoneal Space. The retro-peritoneal space (*supra*) is a name frequently given to the region between the peritoneal cavity and the vertebral column. An analogous region is found in the posterior mediastinum. It is occupied by the kidneys, suprarenal capsules, pancreas, some of the ganglia of the sympathetic nerve-trunk, lymphatic glands, abdominal aorta, inferior vena cava, thoracic duct, and, in the fœtus, by the testis or the ovary.

Partially exposed within it are the descending and transverse portions of the duodenum, and the ascending and descending colon. The cæcum is also commonly uncovered along its posterior border toward the space; but this portion of the canal may be completely covered with peritoneum.

REMARKS.—The retro-peritoneal space is thus a great sac or hiatus within which many diseased processes originate and rapidly spread. The lymphatic glands may here assume enormous proportions, aneurism in the abdominal aorta may occur, and when blood escapes into the space either from bursting of an aneurism or from purpura, it meets with no resistance until the boundaries of the space are reached. (See p. 305.)

The escape of blood, such as that from an aneurism, into the *sub-peritoneal* connective tissue of the abdomen, may compress the cardiac extremity of the stomach and induce dysphagia. If the rupture occurs lower down, it may involve the space between the layers of the great omentum, that between the transverse colon and the spine, and that in front of the pancreas and round the third part of the duodenum. The last structure may become in consequence compressed and obstructed.¹

According to J. Hilton,² the swelling over a rup-

tured kidney cannot reach beyond the middle line of the vertebral column. The serous membrane is attached to the vessels in front of the spine, and limits the spread of the extravasation. In rupture of the abdominal aorta, however, beneath the peritoneum, the blood usually spreads equally on both sides of the spine.¹

The retro-peritoneal space will also afford opportunity for the pus from an empyema to pass downward along the posterior wall of the abdomen, and for the pus of a psoas abscess to ascend to enter the thorax.

The retro-peritoneal space is of great interest to the physician. Morbid processes excited within it are not limited by any well-defined boundary. Blood effused within it can traverse its entire length and even pass upward into the posterior mediastinum, or escape between the layers of the great omentum, between the transverse colon and the spine, in front of the pancreas, or around the transverse portion of the duodenum, which may thus be compressed. Collections of pus in this locality may be either diffused or circumscribed. Such collections may occur at any portion of the space, and may often accompany organic disease. They may be due to transmitted irritation from the bowel or from muscular strain. The two latter causes are more frequently operative along the ascending and the descending colon. An abscess has been detected external to the sigmoid flexure. The most frequent form of such collections is that which occurs behind the ascending colon, particularly at or near the cæcum. Iliac abscess or suppurative perityphlitis excites profound disturbance in the loose texture of the retro-peritoneal space. The pus which successively forms in it as the tissue breaks down may rupture the sheath of the Psoas muscle, perforate the Diaphragm, or reach the thorax through the aortic opening. It may also perforate the great vessels lying within the space, particularly the internal iliac artery and vein.

The omentum may be adherent to the anterior wall of the rectum, where by an unusual coincidence it has aided in closing a perforating ulcer into the peritoneal cavity.²—The lace-like interstices in the omentum have been known to receive knuckles of

¹ J. S. Bristowe, Trans. Path. Soc. Lond., 1859, x. 88; also 1860, 89.

² Guy's Hospital Reports, 1867, 21.

¹ For literature of involvement of the retro-peritoneal space, see J. Chiene, Journ. Anat. and Phys., ii. 218; P. H. Pye-Smith, Guy's Hosp. Rep., 1871, 131; Waldeyer, Virchow's Archiv, lx.; also in Glasgow Medical Journal, 1874, 543; J. P. Irwine, Trans. Path. Soc. London, xxix. 1878, 85.

² T. B. Curling, Diseases of the Testicle, p. 111.

intestines and cause obstruction.—In the bursting of abdominal aneurism, the cavity of the great omentum may be injected with blood.¹

A portion of the omentum may protrude in penetrating wounds of the abdomen, an event that may follow even upon paracentesis.² It may be a constituent in hernia, in which form it may be either diaphragmatic or scrotal.³ Niemann⁴ records a case in which a fold of omentum was caught and held in a traumatic fissure of the liver.

Fat is absent in the mesentery prior to the seventh or the eighth month of foetal life. This fact has been thought sufficiently exact to be of value in determining the age of the embryo, and in this way has been used in forensic medicine.⁵

THE ORGANS OF RESPIRATION.

Under the head of the Organs of Respiration will be described—

- The Larynx.
- The Trachea.
- The Bronchi.
- The Lungs.
- The Pleura.
- The Mediastinal Spaces.

THE LARYNX.

The Larynx (Plates CIII., CIV.) is the organ of voice. It is that portion of the respiratory tract intervening between the pharynx and the trachea. The larynx lies opposite the fourth and fifth cervical vertebrae, and forms the most conspicuous feature in the regional anatomy of the neck, situated as it is between the pharynx behind, and the integument and the thyroid body in front. Above the larynx lies the hyoid bone. The organ is slightly movable from side to side.

The larynx extends from the second to the fifth or sixth cervical vertebra.

The description of the larynx embraces—

- The Cartilages.
- The Ligaments.
- The Muscles.
- The Interior of the Larynx.

THE CARTILAGES OF THE LARYNX.

The Cartilages of the Larynx are five in number—

- The Cricoid.
- The two Arytenoids.
- The two Cartilages of Santorini.
- The two Cartilages of Wrisberg.
- The Thyroid.
- The Cartilage of the Epiglottis.

THE CRICOID CARTILAGE.

The Cricoid Cartilage is placed between the trachea below and the thyroid and arytenoid cartilages above. The thyroid embraces the cricoid cartilage; the arytenoids surmount it. The cricoid cartilage is thicker and stronger than the thyroid, and is extended upward behind, where the thyroid is deficient. It is, as the name expresses, a ring-like cartilage, the antero-posterior diameter being a little longer than the transverse. The anterior part is much smaller than the posterior. The lower border is horizontal and sinuous, while the superior gradually ascends as it passes backward. Toward the upper posterior portion lies a conspicuous rounded facet for articulation with the inferior horn of the thyroid cartilage. On either side of the upper border is an oval eminence directed upward and outward, for articulation with the arytenoid cartilage. The posterior surface is divided in the median line by a slight vertical ridge, which serves as a partial attachment for the œsophagus, while on either side lies a well-defined but shallow depression for the Posterior Crico-Arytenoid muscle. The anterior surface is convex, and affords origin to the Crico-Thyroid muscles, and to part of the Inferior Constrictor. The lower border is slightly produced in front. The mucous membrane lining the cartilage is intimately adherent to the perichondrium.

THE ARYTENOID CARTILAGES.

The Arytenoid Cartilages are two in number. They are situated upon the posterior lateral portion of the upper border of the cricoid cartilage, and within the grasp of the thyroid cartilage. They are the most movable of the laryngeal cartilages, and are important factors in the mechanism of speech. Each cartilage is from five to six lines in height, three lines in width, and one in thickness. The general form of each is that of a pyramid, whose apex is curved inward, so that the upper inner borders approach and may even touch one another.

¹ Young, N. Y. Journ. Med., 1849, 201.

² W. H. Van Buren, N. Y. Journ. of Med., 1849, 333.

³ J. R. Woodworth, N. Y. Med. Journ., xix. 402; also S. S. Smith, N. Y. Journ. of Med., 1851, 218.

⁴ Henke's Zeitschr. für die Staatsarzneikunde, B. 74, 1857.

⁵ Henke, *ibid.* vii. 1844; abstract in Am. Journ. Med. Sci., 1845, 245.

When at rest, the arytenoid is inclined slightly forward, and presents for examination three surfaces, a posterior, median, and anterior; and also a base and an apex.

The posterior surface is triangular, smooth, and concave for the partial attachment of the Arytenoid muscle. The median surface is narrow, but wider below than above. It presents a nearly vertical surface, which is covered by the laryngeal mucous membrane, and serves to limit each side of the inter-arytenoid space. The anterior surface is at the same time directed slightly outward. It is irregularly convex, and is roughened for the attachment of the thyro-arytenoid ligament.

The details of structure upon the anterior surface are more numerous than upon the others, and may be briefly epitomized as follows: At the upper part of the posterior border a slight eminence is seen which is known as the *colliculus* or superior spine. Below the colliculus lies a depression known as the *deltoid fossa*, beneath which, but ascending to define its posterior wall, is an *arched crest* (*erista transversa*) or inferior spine. Adjacent is seen an oblong depression (*fovea oblonga*) for the insertion of the Thyro-Arytenoid muscle. The colliculus can sometimes be seen within the laryngeal image as a slight eminence above the laryngeal pouch.

The *base* presents a deeply arched concavity for articulation with the eminence upon the cricoid cartilage. The posterior end of the base is slightly prolonged, and strengthened on the posterior surface to form the musculo-articular process (*tubercle*) for the insertion of the Crico-Arytenoid muscle. Anteriorly the line of the base is extended beyond the articular facet, which forms a pyramidal process known as the *vocal process*. The vocal process is a conspicuous feature in the outline of the *rima glottidis* as seen in the laryngeal image. It is estimated that its length is from one-third to one-fourth that of the antero-posterior diameter of the glottis. The *apex* of the arytenoid cartilage is formed by a small obliquely-placed plane, to be studied in connection with the following structures.

THE CARTILAGES OF SANTORINI.

The Cartilages of Santorini are conical or cylindrical nodules of fibro-cartilage, which are situated at the upper part or apex of the arytenoid cartilages. They are freely movable, and are, as a rule, united with the arytenoids by synchondrosis, although they may be, according to Cruveilhier, distinct. They form, when covered with mucous membrane, conspicuous rounded eminences upon the posterior margin of the laryngeal aperture.

THE CARTILAGES OF WRISBERG.

The Cartilages of Wrisberg are small, rod-like, or wedge-like nodules of fibro-cartilage, which are lodged between the layers of the aryteno-epiglottic fold, and which are surrounded by mucous glands. The inner extremity commonly projects above the free border of the fold, a little to the outer side of the eminence of the cartilage of Santorini.

G. D. Gibb¹ found the cartilages of Wrisberg larger in the negro race than in the white.

Luschka has described a minute inconstant nodule of cartilage named by him the *sesamoid cartilage*, which is held by a ligament to the outer margin of the arytenoid, between that body and the cartilage of Santorini. He has also directed attention to a pair of minute inconstant structures (Luschka's cartilages) upon the vocal cord near its insertion into the thyroid cartilage. He names the first the *posterior sesamoid* and the second the *anterior sesamoid cartilage*. He mentions the rare existence of a small nodule of cartilage which he names *inter-arytenoid*. It lies upon the posterior aspect of the pharynx, directly beneath the mucous membrane, and is connected to the cartilage of Santorini above by a pair of fibrous cords, and below by a single cord which unites it to the upper border of the cricoid cartilage. Luschka refers to a case in which, owing to its unusual development, a prominence due to the presence of this cartilage was visible in the laryngeal image, and was mistaken for an abscess.

Mucus and other fluids are guided by the posterior boundary of the superior laryngeal aperture to the sides of the pharynx and œsophagus. Thus a single current of a liquid passing downward from the mouth divides into two streams which subsequently commingle in the œsophagus below the larynx.

THE THYROID CARTILAGE.

The Thyroid Cartilage, so called from its resemblance to a shield, incloses and protects the essential parts of the vocal apparatus. It is a symmetrical body, presenting two flanges (*alæ*, sides), which are arranged at an acute angle to each other like the divergent parts of a half-opened screen.

The re-entering angle is placed in the median line, while the sides are directed backward and outward. Each side or wing is quadrangular, and presents for examination an external and an internal surface as well as four borders and two cornua.

The *outer surface* is marked by an oblique line which extends between two marginal tubercles; one of these is situated upon the posterior border at its upper third, the other upon the inferior border. This ridge separates the anterior three-fourths from the

¹ Anthropol. Rev., 1864, 322.

posterior fourth. The Sterno-Thyroid, Thyro-Hyoid, and Inferior Constrictor muscles are attached to this ridge. The smooth surface behind and below it lodges in part the thyroid body. Near the upper border of the outer surface, not far from the base of the greater horn, a foramen is occasionally seen for the transmission of the superior laryngeal artery.

The *inner surface* is smooth and slightly concave. It is related above with the mucous membrane of the pharynx, behind and below with the lateral Crico-Arytenoid muscle.

The *upper border* is larger than the inferior. It is concave directly in front of the base of the greater horn, but convex toward the inner margin, thus making for the entire border a sigmoid curve. At the union of the upper borders of the two plates a deep notch is seen which has received the name of the *thyroid incisure*. The upper border gives attachment to the thyro-hyoid membrane. The *lower border* is wavy, and gives attachment to the Crico-Thyroid muscle, at the sides, as well as to the crico-thyroid membrane. The *posterior border* is free, rounded, and is continuous upward with the corresponding border of the cornu. It gives attachment in part to the Inferior-Constrictor, Stylo-Pharyngeus, and Pharyngo-Staphylinus muscles. The *anterior border* joins the plate of the opposite side.

The *superior cornu* is much larger than the inferior, and is directed upward and slightly backward. Its free extremity affords attachment to the thyro-hyoid ligament. The *inferior cornu* is thick and stout. It is furnished upon its inner surface with a facet for articulation with the cricoid cartilage.

The conjunction of the two plates anteriorly forms the prominence known in the adult male as *Adam's apple*. In the female and in children of both sexes this prominence is less pronounced, and the angle of the plates is less acute than in the adult male. Viewed from behind, the re-entering angle of the two plates presents the following features: First, the upper part for the attachment of the epiglottis, and false vocal cords. Second, the middle part for the attachment of the true vocal cords. Third, the inferior part for the attachment of the Thyro-Arytenoid muscle.

Between Adam's apple and the skin lies a bursa, which ascends perpendicularly to a point near the hyoid bone, and then passes behind it. This bursa is congenital, and apparently belongs to the thyro-hyoid membrane rather than to the thyroid cartilage. It facilitates the gliding of the thyroid cartilage over the anterior border of the hyoid bone.—A bursa has been described lying between the

thyroid cartilage and the hyoid bone. It is occasionally the seat of hypertrophy. This condition has been named "thyro-hyoid cyst" by Gibbs, "sub-hyoidean ranula" by Nélaton, and "hyoidean hygroma" by Mackenzie.

THE CARTILAGE OF THE EPIGLOTTIS.

The Cartilage of the Epiglottis is a vertical, leaf-shaped lamina of fibro-cartilage situated at the front of the larynx. It is broad above and narrow below, where it is attached by a portion of the thyro epiglottic ligament to the re-entering angle of the thyroid cartilage. It is also attached in front at its basal portion to the hyoid bone, to the hyo-epiglottic ligament, and to the base of the tongue, so that its free surfaces are restricted to the posterior aspect and the superior half, nearly, of the cartilage, which is there partially invested with mucous membrane.

The first of the free surfaces constitutes the anterior border of the laryngeal aperture; while the second lies at the base of the tongue.

The posterior surface (laryngeal surface) is concave above, but convex below, where it presents a rounded eminence, the tubercle or cushion. The anterior surface is slightly concave. The margins are for the most part obscured by folds of mucous membrane extending either backward to the arytenoid cartilages, as the *aryteno-epiglottic* (ary-epiglottic) folds, or laterally to the walls of the pharynx, as the *pharyngo-epiglottic* folds, which are often continuous with the *palato-pharyngeal folds*. Between the free portion of the epiglottis and the base of the tongue are three folds of mucous membrane, two *lateral* and one *median*. The *median* fold (epiglottido glossal frenum) is the stoutest of the three, and contains, according to Cruveilhier, some elastic tissue.

The posterior surface of the epiglottis, when the mucous membrane is removed therefrom, is found to be marked by numerous pits for the reception of mucous glands.

REMARKS.—The clinical remarks on the cartilages of the larynx are naturally grouped under the heads of the cartilages themselves.

The cricoid cartilage.—The posterior (pharyngeal) surface of the cricoid cartilage is often the seat of diseased action, inducing pharyngeal spasm and dysphagia.¹ Necrosis, with subsequent inflammatory involvement of the œsophagus, is a recognizable lesion of the cartilage, the sequestrum at times effecting an exit into the pharynx or œsophagus.

The cartilage corresponds to the bodies of the fifth and sixth cervical vertebræ.

¹ W. Gibbs, Trans. Path. Soc. London, 1866, 39.

A transverse line drawn from the cricoid cartilage across the neck would pass over the spot where the Omo-Hyoid muscle crosses the common carotid artery.

The region of the cricoid cartilage is that to which abnormal sensations of the pharynx are often referred. This is doubtless owing to the fact that in irritated states of the pharynx the act of deglutition is painful, and since the cricoid lies at the lower part of the pharynx its motions determine a greater amount of distress than do corresponding motions at any other portion of the throat.—Firm, gentle pressure backward against the cricoid develops pain in laryngeal phthisis, and in the incipient stage of carcinoma of the œsophagus when this disease is located at the upper portion.—The cartilage is relatively more prominent in women than in men, and is often the site to which abnormal sensations are referred by neurotic subjects.

The Arytenoid Cartilages.—The arytenoids are subject to necrosis and to tubercular inflammation.—The mucous membrane over the cartilages is often acutely inflamed in pharyngitis.

The Thyroid Cartilage.—Manipulation of this cartilage is a valuable aid in diagnosis of morbid conditions of the neck; thus, pushing the cartilage downward causes pain in pharyngitis. The cartilage is carried forward in post-pharyngeal abscess.—The thyroid cartilage is more or less translucent, and permits light to be transmitted in the living subject from side to side.¹

A peculiar friction sound is heard by moving the larynx laterally, which is caused by the posterior border of the thyroid cartilage and the posterior surface of the cricoid cartilage moving together with the lower part of the pharynx against the vertebral column. Care should be taken to distinguish between such normal crepitus and that accompanying fracture of the thyroid cartilage. The normal crepitus disappears in retro-pharyngeal abscess, but persists in retro-laryngeal abscess.

In studying cases of suspected fracture of the thyroid cartilage it is important to remember that the upper horn is sometimes found separate from the body.²

Adam's apple may be concealed by œdema and deflected from its position in the median line in post-pharyngeal abscess.

The notch at the upper border of the thyroid cartilage does not appear until puberty.

The Epiglottis. (Fig. 7, Plate XCIX., fig. 5, Plate CIII., Plate CIV.) The shape of the epiglottis appears to be in a measure determined by the condition of the muscles of the pharynx. The cartilage, when narrow, pointed, and deflected backward, is often found associated with a powerful yet fretted pharynx, or at least with one in which a history of pharyngeal distress can be elicited. The cartilage when broad and shallow is often associated with a capacious, tractable pharynx.—The lateral borders of the cartilage may touch the sides of the pharynx either from an unusual increase of the diameters of the cartilage or from thickening or relaxation of the pharynx.

In self-inflicted transverse wounds of the neck (the upper border of the thyroid cartilage being taken as a guide) the epiglottis is divided.—The epiglottis is peculiarly liable to sloughing from tubercular and syphilitic disease.

The epiglottis is an accessory to the closure of the glottis, and also aids in directing the mucus expelled from the trachea into the mouth. The mechanism of passive closure of the glottis as contrasted with active or muscular closure by the constrictor muscles is as follows: the base of the tongue in deglutition presses downward upon the upper surface of the epiglottis while the larynx is raised, and the glottis thereby lies against the under surface. The epiglottis is thus not altered in position, being held between the tongue and the larynx.—It is agreed by observers that the glottis can be closed without the aid of the epiglottis, so that, when this structure is malformed, congenitally absent, or has been lost by disease or injury, deglutition is not necessarily impaired. Larrey,¹ it is true, mentions two cases of gunshot wound involving the loss of the epiglottis, in which dysphagia followed, in one case indeed persisting after cicatrization; and A. Flint, Jr.,² describes a case of syphilitic sloughing of the epiglottis in which cough-

¹ Czernak, Kehlkopfspiegel, Leipzig, 1860, 21.

² Luschka, Virchow's Archiv, 1868, 478.

¹ Mémoires, i. 313.

² Physiology, ii. 200.

EXPLANATION OF PLATE CIII.

Fig. 1. The hyoid bone and the larynx, with ligaments seen from in front.

Fig. 2. The same, seen from the side.

Fig. 3. The hyoid bone, seen from in front.

Fig. 4. The same, seen from above.

Fig. 5. The larynx in position, seen from behind.

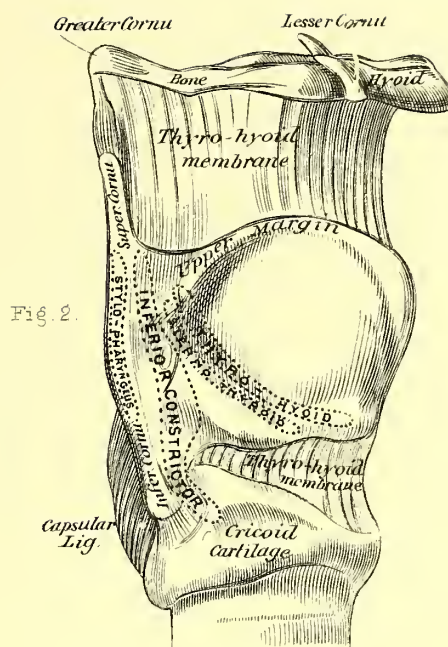
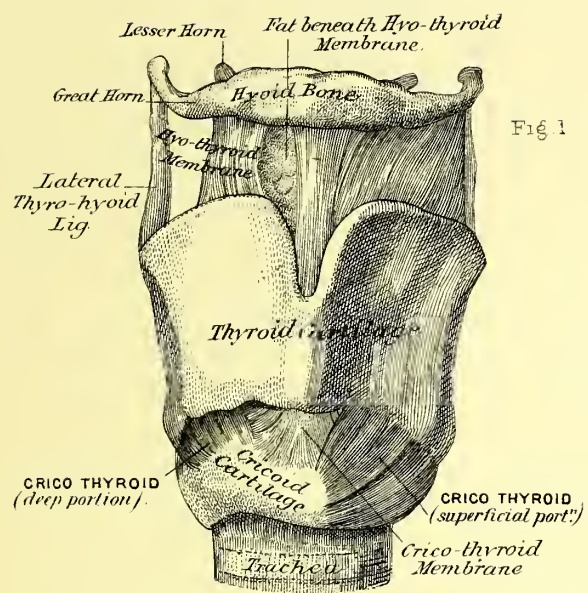


Fig. 3.

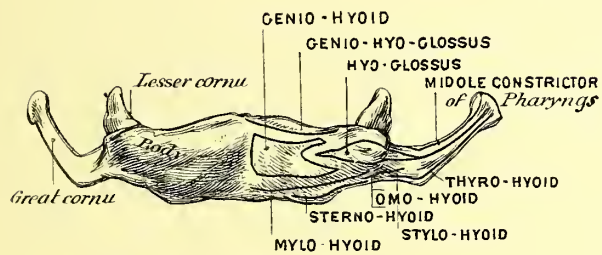


Fig. 5.

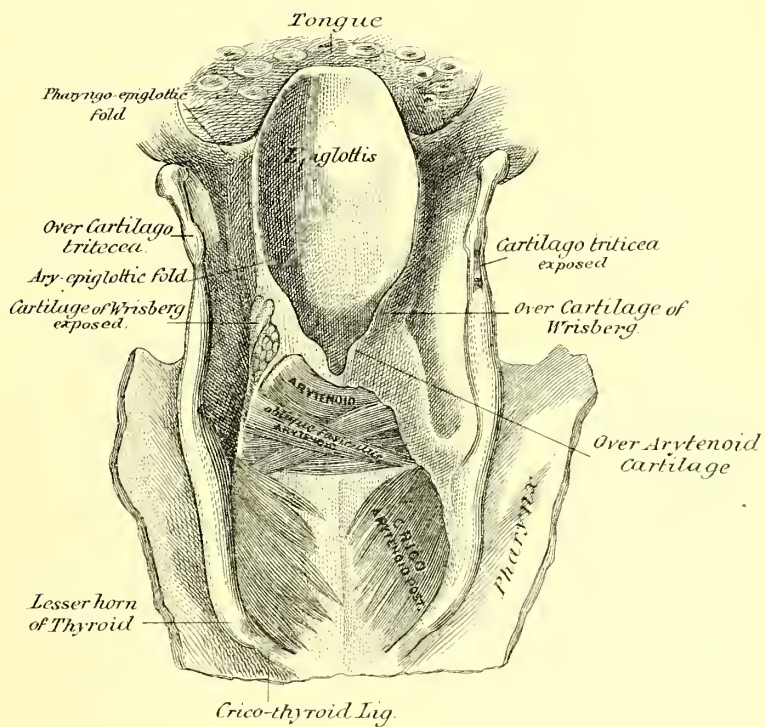
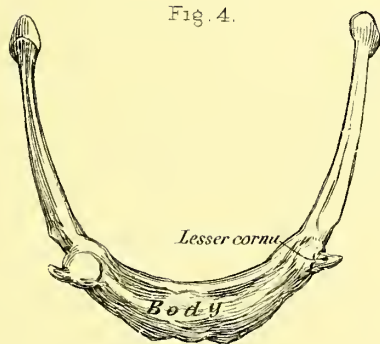


Fig. 4.



ing and general distress always accompanied the act of swallowing while the patient was in the erect position. But it is probable that in both these cases the muscular fibres of the glottis may have become incompetent, either through destruction of their nerves, or by inflammatory infiltration and degeneration.

The base of the epiglottis lies deeply seated behind the hyoid bone, and, strictly speaking, cannot be necrosed or excised. When the epiglottis is mentioned in connection with clinical reports it is accepted that the free portion as seen without dissection is intended. The clinical relations of the deeper structures are chiefly to be studied in connection with the region of the hyoid bone rather than with the region of the larynx.—The resisting fibro-adipose tissue which lies between the hyoid bone and the base of the epiglottis may be the site of a bursa which may become sufficiently large to be brought to the attention of the surgeon.—The bursa over the hyoid bone may communicate with the deeper bursa. The tendency to laryngitis after removal of the hyoid bursa has been repeatedly observed.

THE LIGAMENTS OF THE LARYNX.

The Ligaments of the Larynx (Plate CHH.) are—

- The Thyro-Hyoid Ligament.
- The Crico-Tracheal Ligament.
- The Crico-Thyroid Ligaments.
- The Crico-Arytenoid Ligament.
- The Hyo-Epiglottic Ligament.
- The Thyro-Epiglottic Ligament.

The Thyro-Hyoid Ligament is composed of three parts, a median and two lateral.

The *median ligament* extends between the whole of the upper border of the thyroid cartilage and the upper posterior border of the hyoid bone. It does not, therefore, simply occupy the space between the two structures named, but guides the body of the hyoid bone a little obliquely downward and forward. The membrane is thicker in the middle than at the sides.

A well-defined bursa (infra-hyoid bursa) is intimately connected with the membrane. It ascends to occupy the space between the membrane and the posterior border of the hyoid bone. A second bursa is occasionally seen between the great horn of the hyoid bone and the posterior border of the thyro-hyoid ligament. The membrane is perforated on each side by the superior laryngeal artery and nerve.

The *lateral ligaments* are two in number, one for each side. Each is a short rounded yellow cord

which connects the end of the great cornu of the hyoid bone to the superior cornu of the thyroid cartilage. Each contains ordinarily a nodule of cartilage (cartilago triticea).

The Crico-Tracheal Ligament is a fibrous structure which unites the lower border of the cricoid cartilage with the first tracheal ring. This border is infrequently continuous with the first ring either on the one side or on both.

The Crico-Thyroid Ligaments (crico-thyroid membrane). These are three in number, a median and two lateral.

The *median ligament* is of the shape of a truncated cone, its base being attached to the cricoid cartilage at its upper border, and its apex to the lower border of the thyroid, and also to the vocal membrane within. It is stout and slightly convex in front, and is composed of yellow elastic tissue. It is pierced by one or more openings for the entrance of minute arteries and veins, which supply the laryngeal mucous membrane. It may, however, simply be crossed by an anastomotic arch derived from branches of the right and left superior thyroid arteries.

Each *lateral ligament* presents a stout slip which extends from the cricoid cartilage upward and inward, and an anterior slip which passes upward and outward.

These slips serve to protect a *capsular ligament* lodged between the cricoid and thyroid cartilages.

The Crico-Arytenoid Ligament. Anterior and posterior slips are present, of which the posterior is the stouter. The *capsule* of the crico-arytenoid joint is loose to allow extended motion of the arytenoid upon the cricoid cartilage. Luschka places the facets of this joint among the screw-like articular surfaces.

The Hyo-Epiglottic Ligament. This extends from the hyoid bone upward and backward to the epiglottis.

The Thyro-Epiglottic Ligament extends between the thyroid cartilage and the front of the epiglottis. The space between the two ligaments last named and the epiglottis is occupied by a quantity of fat and fibrous tissue, and by a few glands. In addition to the ligament uniting the thyroid cartilage and epiglottis, a second band is seen uniting the base of the epiglottis to the re-entering angle of the thyroid cartilage.

The vocal membrane.—Between the re-entering angle of the thyroid cartilage and the vocal process of each arytenoid, extends the *Inferior Thyro-Arytenoid* ligament, which, when covered with mucous membrane, constitutes the *true vocal cord* of the laryngeal

image. Extending laterally from this ligament, and downward to the superior border of the cricoid cartilage, is the *vocal membrane*, which is continuous in front with the median portion of the crico-thyroid ligament. The upper border of this membrane, with the vocal cord to which it is attached, forms the lower boundary of the *laryngeal pouch*.

Stretching along the upper border of the laryngeal pouch is a membrane, known as the *superior thyro-arytenoid ligament* or the *false vocal cord* of the laryngeal image.

In addition to these structures the larynx exhibits several elevations of the mucous membrane which have received the name of ligaments, without, however, strictly deserving this name. These are formed by prominences of pharyngeal fascia covered with mucous membrane. The most important fold of this description, pertaining to the interior of the larynx, is the ary-epiglottic. The ary-epiglottic ligament forms the lateral border of the aperture of the larynx, and extends between the tip of the arytenoid eminence and the side of the epiglottis. It contains the cartilage of Wrisberg, and along its free border is the seat of a number of mucous glands. It is continuous at its base with the eminence of the false vocal cord.

Tourtual and Lusehka have described the membranous lining of the larynx as a continuous structure—the lower part terminating at the true vocal cord; the middle part lining the laryngeal pouch, and ending in the false vocal cord; the upper part forming a quadrangular membrane, which terminates at the ary-epiglottic fold.

REMARKS.—The thyro-hyoid ligament may be ruptured, as occurred in a case of J. H. Stallard.¹ A man, aged forty-four, suffering from phthisis, with laryngeal irritation, “felt something give way during a paroxysm of coughing. On examination, the right greater cornu of the hyoid bone was felt to be loose beneath the integument. It was separated by at least

an inch and a half from the thyroid cartilage. During deglutition the hyoid bone was drawn upward, and the larynx tilted downward at the posterior part, thus increasing the distance between the thyroid cartilage and the hyoid bone, the connection being maintained in front only by the thyro-hyoid membrane.”

A small lymphatic gland lies upon the thyro-hyoid membrane beneath the Thyro-Hyoid muscle. Enlargement of this gland may induce dysphagia and dyspnoea. Occasionally it is the seat of encephaloid cancer. A case of the latter mentioned by A. Burns¹ was remarkable for extending inward and upward along the pharyngeal wall.

Thyro-hyoid abscess has its seat in a mass of cellular tissue occupying a space behind the thyro-hyoid membrane, close to the base of the epiglottis. The suppurative inflammation of this part of the throat may be idiopathic, or may be symptomatic of an affection of the tongue, of the epiglottis, or of the thyroid cartilage. It may create œdema in the sub-epiglottic connective tissue, and in that of the ary-epiglottic ligaments, besides forcing the epiglottis upon the laryngeal aperture. The abscess extends toward the mouth, and its projection can sometimes be felt in the fossa between the base of the tongue and the epiglottis.

THE MUSCLES OF THE LARYNX.

The Muscles of the Larynx (Plates CIII., CIV.) are—

The Crico-Thyroid.
The Posterior Crico-Arytenoid.
The Lateral Crico-Arytenoid.
The Arytenoid.
The Thyro-Arytenoid.
The Thyro-Epiglottideus.
The Aryteno-Epiglottideus.

¹ Trans. Path. Soc. Lond., 1860, xi. 36.

¹ Surg. Anat. of Neck, 118.

EXPLANATION OF PLATE CIV.

Fig. 1. The larynx opened from behind; the left side with structures dissected from the interior aspect; the right side is displayed in sinistro-dextral transverse (frontal) section.

Fig. 2. The larynx, trachea, and bronchial tubes in position, seen from in front.

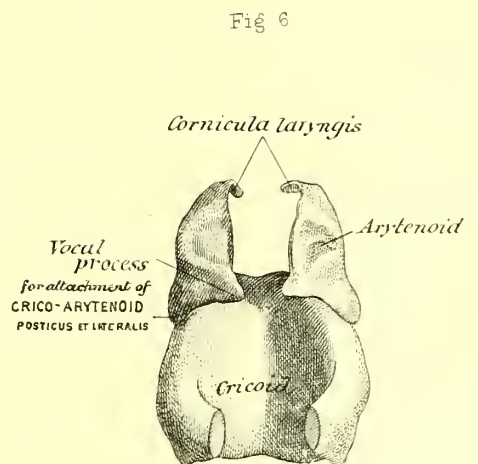
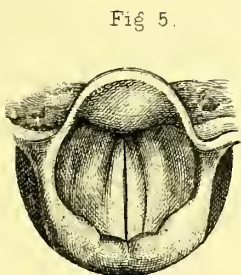
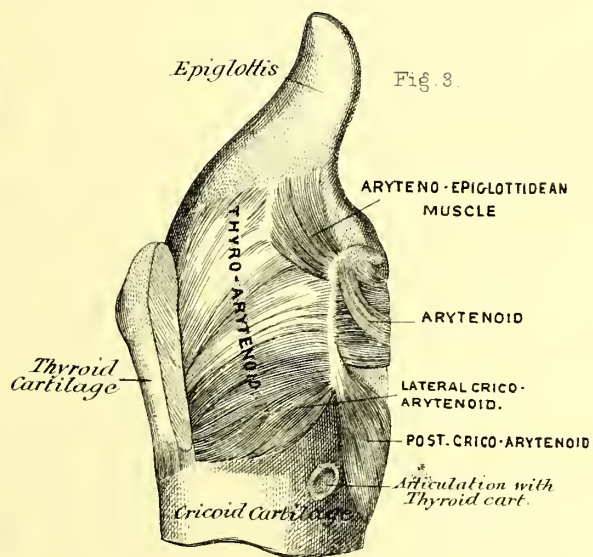
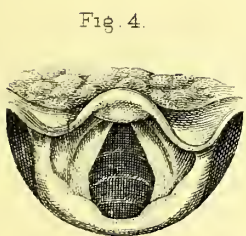
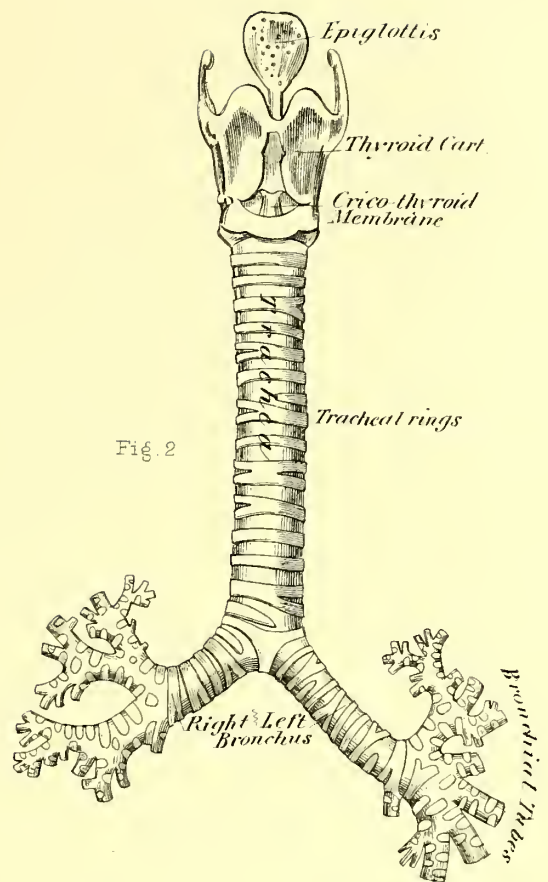
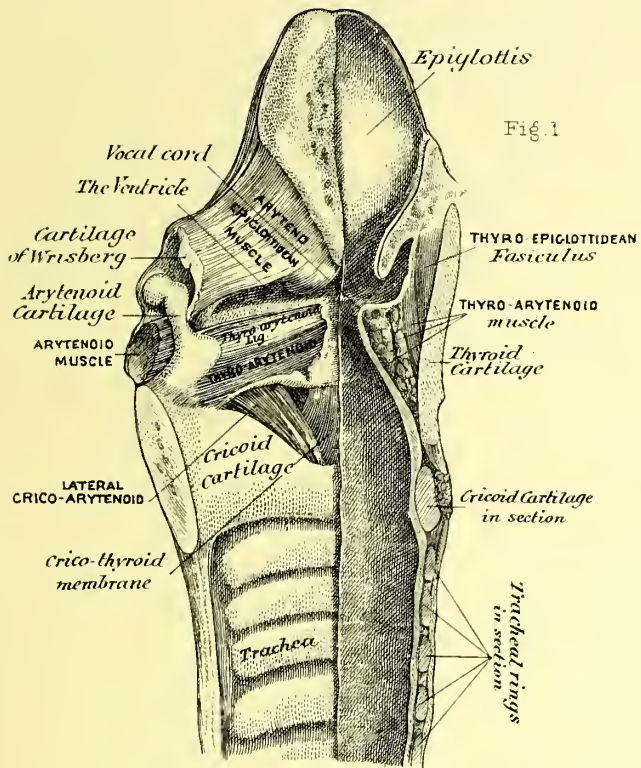
Fig. 3. The larynx, so displayed as to give a view of the

intrinsic muscles, after the removal of one side of the thyroid cartilage.

Fig. 4. The laryngeal image, seen by reflected light, showing the vocal cords abducted.

Fig. 5. The same, showing the vocal cords adducted.

Fig. 6. The cricoid cartilage, the arytenoid cartilage, and the cartilages of Santorini. The structures last mentioned have been named *cornicula laryngis*.



The Crico-Thyroid is a short triangular muscle which arises from the side of the cricoid cartilage. Its diverging fibres pass upward and outward, and are inserted into the thyroid cartilage, from the base of the lower cornu forward to near the median line.

Action.—The Crico-Thyroid has a fixed point of origin in the cricoid. It draws the thyroid cartilage down toward this origin, and thus makes tense the vocal cord indirectly. The motion of the thyroid cartilage while downward is also somewhat rotatory forward.¹

Some of the more superficial fibres of this muscle may be traced into the Inferior Constrictor. The lower fasciculus is composed of nearly horizontal fibres, and is sometimes distinct. A triangular space is left between the anterior border of the Crico-Thyroid muscles, thus exposing the crico-thyroid membrane. An inconstant slip extends from the cricoid cartilage to the lower end of the inferior cornu of the thyroid cartilage, forming the Kerato-Cricoid muscle.

The Posterior Crico-Arytenoid muscle arises from the entire lateral half of the posterior surface of the cricoid cartilage. The muscle is in consequence broad and somewhat quadrangular. Its fibres pass upward and outward, and are inserted into the outer part of the musculo-articular process of the arytenoid cartilage.

Action.—To abduct and rotate the arytenoid cartilage, and in consequence to abduct the vocal cord.

The Lateral Crico-Arytenoid muscle arises from the upper margin of the side of the cricoid cartilage. It is a small slip compared with the Posterior Crico-Arytenoid, and is apt to be continuous at its upper margin with the Thyro-Arytenoid. Passing upward and backward, it is inserted into the musculo-articular process of the arytenoid cartilage in front of the insertion of the preceding muscle.

Action.—To adduct the arytenoid cartilages, and in consequence the vocal cord.

The muscle is concealed from without by the thyroid cartilage; and upon its anterior part it is covered by the upper part of the Crico-Thyroid muscle.

The Arytenoid is a single muscle, although occupying the posterior surfaces of both arytenoid cartilages. It is composed of two sets of fibres, a deep circular, the shorter of the two, often spoken of as the *true arytenoid*, and a superficial oblique set,

divided into two parts, which cross each other at an oblique angle. The latter are continuous anteriorly with the outer layer of the Thyro-Arytenoid muscle, or with fasciculi of the Thyro Epiglottideus muscle.

Action.—To bring closely into apposition the arytenoid cartilages and aid in adducting the vocal cords.

Merkel has described a *filtrum ventriculi* by means of which the laryngeal pouch empties its secretion into the pharynx.

The Thyro-Arytenoid muscle (vocal muscle) arises from the lower part of the re-entering angle of the thyroid cartilage, and passes as a broad thin ribbon of straight muscular fibres horizontally across the side of the anterior portion of the larynx, just beneath the vocal cord, to be inserted into the vocal process of the arytenoid cartilage.

Action.—To draw the arytenoid cartilage forward and thus relax the vocal cord, and to give tonicity to the vocal cord itself.

This muscle is of great complexity, and presents a range of variation perhaps unequalled among the muscles of the body. Its general plan may be said to present an *internal* and an *external* fasciculation, of which the internal preserves an intimate relation to the vocal membrane, and, what is especially noticeable, controls the free border of this membrane at the laryngeal pouch. It is inserted at the fovea oblonga and the vocal process of the arytenoid cartilage. The external portion, at first intimately associated with the internal, is, on the whole, less compact, and sends delicate bundles upward toward the outer wall of the laryngeal pouch to the inner border of the arytenoid cartilage.

Luschka describes, after Santorini, a distinct fasciculus which, while receiving the name of the Thyro-Arytenoideus Superior, is in many respects distinct from the above. It arises from the base of the notch of the thyroid cartilage at the posterior margin, and is inserted into the musculo-articular process of the arytenoid cartilage, or may send slips downward to the cricoid cartilage or the crico-thyroid membrane.

Still other fasciculi, which constitute the Thyro-Aryteno-Epiglottic muscle, pass between the points named as a thin layer of inconstant fibres. They aid in forming the *oblique portion* of the Thyro-Arytenoid muscle.

The Thyro-Epiglottideus muscle is an irregular delicate fasciculus which arises from the re-entering angle of the thyroid cartilage to the outer side of the Thyro-Arytenoid, and ascends to be inserted upon the sides of the epiglottis.

Action.—To depress the epiglottis and assist in closing the superior aperture of the larynx.

The Aryteno-Epiglottideus muscle is upon the same plane as that of the preceding. It arises from the arytenoid cartilage, and is inserted upon the epiglottis.

¹ It was formerly supposed that the cricoid cartilage muscle was moved upward instead of the thyroid cartilage being moved downward. The expression in the text is based upon the researches of F. H. Hooper, Trans. Am. Laryngolog. Ass'n., 1883, 118.

The lower division of these fibres has been named by Hilton the Compressor Sacculi Laryngis.

Slips from both the muscles last named accompany and are continuous with the superficial interwoven fibres of the Arytenoid muscle. Both are continuous with each other, and constitute the Thyro-Aryteno-Epiglottideus muscle of Henle.

REMARKS.—Acquaintance with the muscles of the larynx is essential to the correct interpretation of alterations of voice as dependent upon disease. Thus, the paralysis of the *adductors* of the vocal cords (the Lateral Crico-Arytenoid and the Arytenoid) causes abduction of the cords. Occasionally the Lateral Crico-Arytenoid of one side only may be the seat of degenerative change. Spasm of the adductors is the essential phenomenon of laryngismus stridulus.

Paralysis of the *abductors* of the vocal cords (the Posterior Crico Arytenoid muscles) causes adduction of the cords. When bilateral it creates a condition dangerous to life by reason of the resultant complete adduction of the cords. M. Mackenzie¹ narrates two instances of involvement of the recurrent laryngeal nerve and consequent paralysis and degeneration of the above muscles. In one of these the patient was a male fifty years of age. An extensive cancerous growth had incorporated itself with the left recurrent nerve at a point at which it passes beneath the arch of the aorta. In the other instance,² that of a female aged twenty-six, a number of small and apparently benign tumors had developed near the trachea. One of these involved the left recurrent nerve in such a manner that the nerve appeared to be completely imbedded in the growth.

The *tensors* of the vocal cords—the Crico-Thyroids, as well as the *laxators* of the vocal cords, the Thyro-Arytenoids, may be all or severally diseased. Paralysis of the Thyro-Epiglottideus muscle may ensue upon diphtheria and progressive bulbar paralysis.—In the event of impairment of the function of the Thyro-Arytenoid muscle the condition is usually followed by an abnormally high pitched voice. This result may also ensue upon defective development of the muscle. The loss of voice, so frequently noticed in neurotic females, is usually due to paresis of this muscle.

THE INTERIOR OF THE LARYNX.

The Interior of the Larynx (figs. 1, 4, 5, Plate CIV.) is covered throughout with mucous membrane, which in some measure conceals the plan of the car-

tilaginous framework. It is divided at the position of the true vocal cords into two portions or regions, the *supra-glottic* and the *infra-glottic*.

The *supra-glottic* portion, which extends from the tip of the epiglottis to the true vocal cords, is wide, of a varied outline, more movable, and is furnished with a thicker mucous membrane, as compared with the *infra-glottic* portion; this portion presents a nearly circular outline, is almost immobile, and its mucous membrane is everywhere smooth, thin, and adherent. The diameter of both regions abruptly narrows at the glottis, so that the interior of the larynx can be happily compared to an hour-glass. This resemblance is best seen in a right and left vertical section of the adult larynx.

The supra-glottic portion presents for examination the pharyngo-laryngeal sinus and the vestibule of the larynx.

The Pharyngo-Laryngeal Sinus (pyramidal sinus) is a relatively unimportant space between the inner wall of the thyroid cartilage and the outer wall of the vestibule as defined by the quadrangular membrane, and by the thyro-hyoid membrane and hyoid bone above. It has no connection with phonation, and is lined with mucous membrane having characteristics in common with that of the pharynx. It is often the seat of inflammation or of ulceration, and affords lodgment for foreign bodies.

The Vestibule of the Larynx is bounded above by the superior laryngeal aperture, below by the rima glottidis, and on the sides by the quadrangular membrane, the ventricle, and the false vocal cord.

It will be described as the interior is approached from above downward.

The Superior Laryngeal Aperture is of a triangular or cordiform figure, the apex of which is forward and the base backward. It is oblique from before backward and from above downward. In front is the epiglottis, from the side of which extend the aryteno-epiglottic folds; these terminate at the eminences of the cartilages of Santorini. To the outer side of the latter are seen the eminences for the cartilages of Wrisberg. At the median line of the posterior border is a deep vertical notch, the *inter-arytenoid space*, which is limited below by the cricoid cartilage and at the sides by the inner borders of the arytenoid cartilages.

The Arytenoid Glands. Along the aryteno-epiglottic border posteriorly are a number of racemose glands, which surround the eminences of the cartilages of Wrisberg. At the inner margin of the arytenoid cartilage they descend abruptly into the vesti-

¹ Lond. Hosp. Rep., 1867, 107.

² Trans. Path. Soc. London, 1868, 84.

bule, to form a ridge-like eminence of mucous membrane from the superior laryngeal aperture to near the ventricle. They may thus be described as having a horizontal and a vertical arrangement. Between this ridge and the anterior border of the arytenoid cartilage is a groove, called the *filtrum ventriculi* by Meckel, who supposed it to aid in the conduction of mucus from the ventricle to the pharynx.

The Quadrangular Membrane.—The side of the vestibule, which extends between the aryteno-epiglottic fold and the false vocal cord, has received from Tourtual the name of the quadrangular membrane.

The so-called False Vocal Cord (ventricular band) is a ridge-like eminence of mucous membrane extending from before backward across the side of the vestibule, and lying between the quadrangular membrane above and the ventricle below. It is covered with thin mucous membrane which is firmly adherent to the superior thyro-arytenoid ligament. The false vocal cord has no important function as far as is known. From its extreme sensitiveness it has been supposed by Luschka to serve as a monitor to the true vocal cord. The two bands may be approximated by the constrictor-like fibres of the Thyro Arytenoid muscles.

The Ventricle of the Larynx (ventricle of Morgagni, laryngeal pouch). Between the true and false vocal cords is the elliptical orifice (rima) of the ventricle of the larynx. The *upper border* of the ventricle is somewhat curved upward; the lower is straight. The ventricle is narrow at the orifice, but is prolonged upward for about six lines in the space between the quadrangular membrane and the inner surface of the thyroid cartilage. As it ascends it curves slightly backward. This ascending portion is often spoken of as the *sacculi laryngis* (sac of Hilton), although this name is also applied to the ventricle. It may reach the upper border of the thyroid cartilage, and even pass beyond it. Luschka has recorded an example in which the top of the sac lay beneath the mucous membrane of the tongue. The ventricle receives the secretions from sixty or seventy small racemose glands, which are imbedded in the submucous and delicate fat tissue surrounding the sac. They are here surrounded by a membrane which is continuous with the false vocal cords. The glands are the occasional seat of cysts of retention. Bruns has described a case of this kind in which the tumor protruded into the cavity of the vestibule through the orifice of the larynx. Luschka found in one case a cyst of the size of a walnut, which lay be-

neath the Thyro-Hyoid muscle, and had apparently escaped detection during life.

The *anterior border of the vestibule* is formed by the *cushion of the epiglottis* and part of the *fovea centralis*. The cushion is composed of glands and a quantity of fat.

The *fovea centralis* is a small groove upon the anterior surface of the larynx at the re-entering angle of the thyroid cartilage. Its existence is determined by the want of absolute approximation of the true and false vocal cords.

The Glottis.—The glottis is that part of the larynx in which the true vocal cords are situated. It lies between the re-entering angle of the thyroid cartilage and the bases of the arytenoids, and resembles a narrow triangle in shape, having its base posteriorly. It is bounded in front by the fovea centralis, at the side by the vocal cords and vocal processes, forming the lips of the glottis, and behind by the inter-arytenoid notch. The opening between the cords is called the *chink of the glottis* (*rima glottidis*). It is eleven lines long in the male, and nine in the female, with a width, in easy respiration, of three or four lines. Each vocal cord is prismatic, having its base outward. Its upper border is horizontal; its lower extends obliquely downward and outward. Much of its bulk is due to the presence of the Thyro-Arytenoid muscle beneath the mucous membrane.

Luschka^{*} speaks of that portion of the chink between the vocal cords as the *inter-ligamentous rima*, and of that between the vocal processes as the *inter-cartilaginous rima*.

The *mucous membrane of the larynx* is loose on the anterior surface and the free border of the epiglottis, but firmly adherent and smooth on the posterior surface. It is also loose on the posterior surface of the arytenoids; on the aryteno-epiglottic folds to permit free motion of the arytenoid cartilages; as well as in the laryngo-pharyngeal sinus, and within the laryngeal pouch. It is adherent to adjacent structures at the quadrangular membrane, also at the true and false vocal cords and in all of the infra-glottic region.

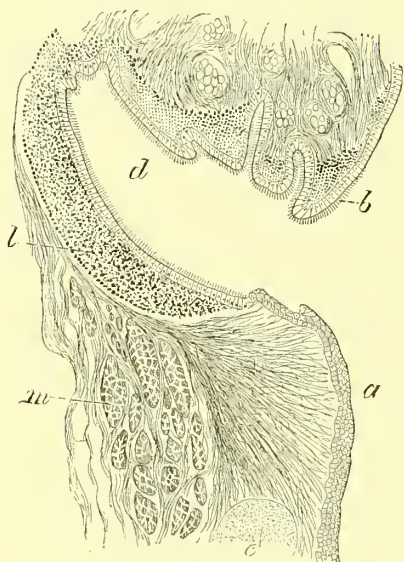
In consequence of the arrangement above described, œdematous conditions are common on the anterior surface of the epiglottis, and round the superior aperture of the larynx, while they are rare elsewhere.

The *epithelium* is of the ciliated variety except where it lines the inter-arytenoid space and thence to the glottis where it is squamous.

The mucous membrane varies in color from a delicate yellowish-pink on the margin of the epiglottis,

to a deep pink or light red at its base down into the vestibule. The false vocal cords are of a light pink hue, while the true vocal cords are of a pearly or yellowish-white.

Fig. 186.



From a longitudinal section through the ventricle of the larynx of a child. *a*, True vocal cord; *b*, false vocal cord; *c*, a nodule of elastic cartilage; *d*, ventricle; *l*, lymphatic tissue; *m*, bundles of the Thyro-Arytenoid muscle in transverse section.

According to P. Coëen,¹ the vocal cord may contain a few minute racemose glands.

The Infra-Glottic Region of the larynx is a rounded space corresponding in shape nearly to the general outline of the cricoid cartilage, but somewhat modified at the side by the lower two of the crico-thyroid ligaments. Its junction with the trachea may be called the *inferior aperture of the larynx*. The mucous membrane is everywhere smooth and adherent, resembling in general appearance that of the larynx.

The Laryngeal Image.—At the risk of repeating in part the description of the larynx, the account of the laryngeal image will include the following: The laryngeal image is a foreshortened view of the parts included within the laryngeal aperture when seen reflected in the laryngeal mirror. Describing the component parts of the image from above downward, since the anterior border of the laryngeal aperture is also the upper border of the image, the first structures seen are the cervical free edge and the cushioning base of the *epiglottis*. The epiglottis may be curved forward, may be thickened and so in-

clined as partially, if not entirely, to obscure the parts lying below the plane of the aperture. At the sides of the aperture are seen the *aryteno-epiglottic folds*, together with the *eminences of the cartilages of Wrisberg and Santorini*. The latter surmounts the arytenoid cartilage, which moves coincidently with it. The *base of the arytenoid* itself may be determined to the median side of the cartilage of Santorini. Between the bases of the arytenoid cartilages is seen the *inter-arytenoid notch*. Lying within the aperture, but on a lower plane, extending across the angle formed by the junction of the contour of the epiglottis with that of the aryteno-epiglottic fold, is the *false vocal cord*. Lying to the median side of the pinkish false vocal cord is seen the *true vocal cord*, which extends across the plane of the laryngeal aperture in a nearly straight line.

The inferior third of the true vocal cord represents the vocal process of the arytenoid cartilage; it is of a yellow or white color, and is rigid in form. The superior two-thirds represents the position of the Thyro-Arytenoid muscle and the mucous membrane over it. It is of a delicate pearl tint, and is vibratile in many of the acts of speech.

The chink lying between the false and the true vocal cords corresponds to the position of the orifice of the *ventricle*, while the space between the true vocal cords is recognized as the *glottis*. In favorable subjects a few tracheal rings, and even the orifices of the place of division of the bronchial tubes, also can be seen.

The relations between the several parts of the image undergo changes in respiration and in speech. The most striking of these consist of the widening or narrowing of the inter-arytenoid space and of the glottis. When the inter-arytenoid space is widened the baggy mucous membrane over the arytenoid eminence and the cartilages of Santorini are seen lying as a broad smooth ellipse against the posterior wall of the pharynx; when the space is narrowed the mucous membrane is somewhat corrugated, and to a slight degree removed from contact with the pharynx. When the glottis is widened the tracheal rings may be seen through a wide, nearly lozenge-shaped space, each border of the true vocal cord being slightly angulated at the point where the vocal process of the arytenoid cartilage is defined.

When the glottis is narrowed the shape of the interspace between the cords varies according to the relative disposition of the vocal processes and of the vibratile portion of the true vocal cords. These are subject to contrasts, as the parts are disposed to emit

¹ Archiv. de Physiologie norm. et pathol., 1874, 92. Pl. vi.

certain sounds either for speech, or for the creation of musical tone, and need not be analyzed in this place.

Edema of the larynx differs in its physical features whether it be above or below the glottis. The differences in the mucous surfaces already mentioned are of great influence in the localization of this disease. As defined by clinical writers the *supra-glottic œdema* is the more frequent of the two forms. The swelling is pronounced, ordinarily involves the false vocal cords, and is accompanied by submucous infiltration. It has sometimes been described as hanging down like a bag, so as completely to fill the chink of the glottis. *Infra-glottic œdema*, a rarer affection, is accompanied by relatively little swelling, owing to the more intimate association here existing between the mucous membrane and the cricoid cartilage. Annular masses of mucus may be formed in this condition of the larynx.—Moxon¹ describes an eversion of the lining of the ventricle of the larynx. At first sight it appeared to be a tumor hanging down over one of the vocal cords, semi-elliptical in shape, and attached above in the anterior half of the ventricle of the larynx. On examination it was found that the everted portion could easily be put up into the usual position of the saccus of the larynx, and when so placed it appeared as the saccus laryngis.

Hyrtl² describes a delicate fold extending from the epiglottis to the hyoid bone.

Bloodvessels.—The larynx is supplied with branches of the superior and inferior thyroid arteries. The mucous membrane is supplied by the superior and inferior laryngeal arteries. The Crico-Thyroid, the Aryteno-Epiglottideus, and the Thyro-Epiglottideus are supplied by the superior laryngeal, the first-named by a separate branch which is called by some writers the crico-thyroid branch. The Thyro-Arytænoidei, the Crico-Arytænoidei, and the Arytænoidei are supplied by both the superior laryngeal and the inferior laryngeal arteries.

The *veins* of the mucous membrane and of the muscles of the larynx are tributary to the superior thyroid and inferior thyroid veins, and thence to the internal jugular.

Nerves.—The nerves of the larynx are derived from the pneumogastric. The mucous membrane and the Crico-Thyroid muscles are supplied by the superior laryngeal nerve, and the remaining muscles by the inferior laryngeal.

Lymphatics.—The lymphatic tissue of the larynx is abundant (Fig. 186). The lymphatic vessels pass to the deep lymphatic glands of the neck.

THE TRACHEA.

The Trachea (fig. 2, Plate CIV., Plate CV., Plate CVI.) is that portion of the respiratory tract which is placed between the larynx and the bronchi.

The trachea is a nearly cylindrical tube broader below than above, and composed of from sixteen to twenty C-shaped cartilages which are separated by narrow intervening spaces. The cartilages define the trachea in front and at the sides; behind, the tube is formed by a flat yielding membrane which unites the ends of the cartilages.

The trachea measures from four to four-and-a-half inches in length, three-fourths to one inch in width. It is somewhat more capacious in the male than in the female.

Relations.—The trachea extends from the fifth cervical vertebra to the third or the fourth or even to the fifth dorsal vertebra. The upper two-thirds of the tube lie in the region of the neck, and the lower third in the thorax. While lying in the middle line of the neck and of the trunk the trachea is freely movable from side to side. The trachea is closely invested in a delicate but resisting fascia (fascia laryngo-trachealis, fascia thyro-trachealis). The relations are consecutively grouped as follows: the cervical and the thoracic. The *cervical relations*. In front, covering the second, third, and fourth rings, lie the isthmus of the thyroid body, the Sterno-Hyoid and Sterno-Thyroid muscles, the deep cervical fascia, some intercommunicating branches of the anterior jugular veins, the inferior thyroid vein, and occasionally the *arteria thyroidea ima*. Near the sternum the trachea is crossed by the innominate artery. At the sides lie the lobes of the thyroid body and the common carotid artery, the inferior thyroid artery, and the recurrent laryngeal nerve. Behind lies the œsophagus.—The *thoracic relations*. The trachea lies in the middle mediastinum between the pleuræ. In front lie the Sterno-Hyoid and Sterno-Thyroid muscles and the manubrium of the sternum. Behind, the trachea rests upon the œsophagus, though this tube inclines to pass to the left side. On the right side the trachea is nearer the pleura than toward the left, while on the left it is nearer the left carotid artery than is the right near the right carotid artery. The pneumogastric nerves lie on either side of the trachea.

The trachea divides into the bronchi about opposite the spine of the fourth dorsal vertebra, and opposite the junction of the manubrium and gladiolus.

Structure.—The C-like cartilages are flat in front, and are more or less imbedded in fibrous tissue. They are convex behind, and are here conspicuous when seen from within the trachea. The first cartilage is often broader than the

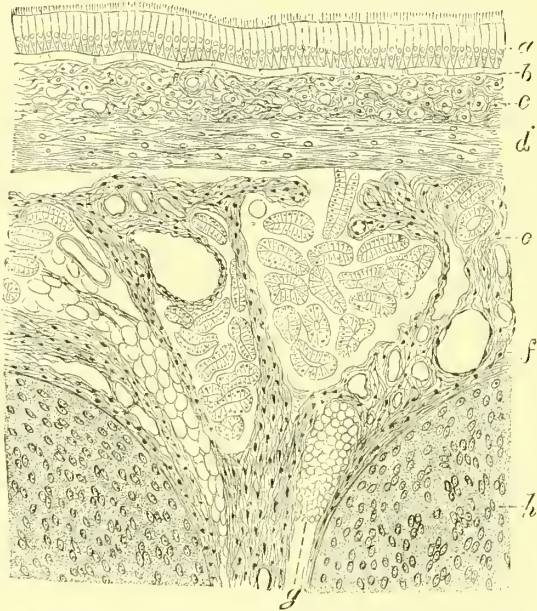
¹ Trans. Path. Soc. Lond., 1868, 65. See, also, G. M. Lefferts, Am. Journ. Med. Sci., 1878.

² Sitzungsberichte, Wien. Acad. xxv.

others, and is apt to be united at the sides with the lower border of the cricoid cartilage. The lower border of each ring is often furnished with one or more irregular or simple processes. The last tracheal ring, which lies at the bifurcation of the bronchi, is of a triangular shape.

The posterior membranous portion of the trachea is composed of fibro-elastic and muscular tissue. The *fibrous layer* is continuous around the entire tube in front, and at the sides partially imbedding the tracheal rings. It is continuous above with the perichondrium of the cricoid cartilage. The elastic layer, composed of fibres which are arranged longitudinally, occupies the spaces between the rings, and is intimately connected with the mucous membrane. The mucous membrane is marked near the bifurcation of the bronchi by a few faintly developed longitudinal folds.

Fig. 187.



From a longitudinal section through the trachea of a child. *a*, The stratified columnar ciliated epithelium of the internal free surface; *b*, the basement membrane; *c*, the mucosa; *d*, the networks of longitudinal elastic fibres; the oval nuclei between them indicate connective-tissue corpuscles; *e*, the submucous tissue containing mucous glands; *f*, large bloodvessels; *g*, fat-cells; *h*, hyaline cartilage of the tracheal rings.

The muscular layer is thin, and composed of pale, unstriated fibres, which are confined for the most part to transverse bundles entering the incurved ends of the C-like cartilages. The muscle-layer is crossed by sparsely distributed longitudinal fasciculi. To the outer side of or incorporated with the layer are occasionally seen small nodules of cartilage called by Luschka the intercalary cartilages.

The *mucous membrane* is thin and of a yellowish-red color. It is firmly adherent by means of elastic fibres to the elastic coat, and is covered everywhere with ciliated epithelium.

The glands opening upon the trachea are of the racemose type, those upon the posterior wall of the tube being the best developed. Rokitsky has described retention cysts of these glands under the name of tracheoceles.

Bloodvessels.—The *arteries* of the trachea in the neck are derived from the tracheal branches of the inferior thyroid arteries. The *veins* in the neck contribute to the inferior thyroid veins and thence to the innominate veins.

The *nerves* are derived from the recurrent branches of the pneumogastric nerve.

The *lymphatics* in the neck pass to the inferior deep lymphatic glands of the same region.

In the *thorax* the trachea receives twigs from the aorta; the nerves are derived from the pneumogastric, and the lymphatic vessels join the tracheal glands.

Variations.—The trachea has been found by Serres¹ duplicated in a specimen of heterodelphia. It may end blindly a short distance below the cricoid cartilage or be at about the same level fused with oesophagus. For other defects see Oesophagus.

REMARKS.—The trachea is peculiarly exposed to causes of compression, not only because of the position occupied by it in the neck, but because of the yielding character of the tracheal walls. Besides, its tract lies in regions which are liable to many grave morbid processes, among which may be mentioned goitre, sarcoma, aneurism of the great vessels, enlargements of lymphatic glands, and diseases of the clavicles, ribs, and sternum. It is thus liable to be deflected from the median line—a fact of importance to remember in the operation of tracheotomy in an adult having a cervical tumor. The trachea is also liable to intra-mural changes, chiefly of a fibroid character, which narrow its lumen and impede the ingress and the egress of air. The trachea is frequently invaded by disease originating in other structures. Thus a tuberculous abscess has been known to ulcerate through the tracheal walls and cause death by suffocation. Cancer is a frequent cause of tracheal involvement, either by extending forward from the oesophagus, or by pressure from cancerous cervical or thoracic lymphatic glands. Aneurism, particularly the intra-thoracic form, may give rise to hemorrhage into its lumen. The trachea may be compressed at the point of bifurcation by lymphatic glands and induce symptoms of suffocation. Abscess of the lymphatic glands in this position may open into the trachea or bronchial tubes. It yields not only to the slow processes of disease, but to injuries as well. In the thorax its position protects it from all injuries but penetrating wounds. In the neck it is otherwise, and, especially when the head is thrown backward, the trachea may be ruptured

¹ Mus. d'Hist. Nat. xv. 1827, 4.

by a blow, or the contusion of a carriage wheel. The trachea has been ruptured by the act of coughing.¹ A polyp of the trachea is described by W. C. B. Tifield² which acted like a ball-valve at the orifice of the left bronchus, permitting expiration but impeding inspiration.

Fracture of the larynx and rupture of the trachea are serious lesions. W. Hunt³ found in studying the literature of twenty-seven cases that seventeen died. J. Atlee has reported a case of complete loss of continuity in the cervical portion of the trachea in a child, which resulted in death in a few moments.

THE BRONCHI.

The trachea terminates in two branches, the right and left bronchi (fig. 2, Plate CIV., Plate CV.). The right bronchus, composed of six or eight rings, is the larger, though the shorter of the two, and passes downward and outward on the level of the fourth dorsal vertebra. It divides into two (and sometimes three) branches, of which the upper and smaller passes to the upper lobe of the lung. The bronchi subdivide into smaller passages called bronchial tubes.

The left bronchus measures two inches in length, and is directed downward and outward at the level of the fifth dorsal vertebra. It is composed of from nine to twelve rings.

According to Sappey, the bronchi near their origin correspond in front to the second intercostal space.

REMARKS.—Hyrtl has found that the right lung of the newly born infant is the first to be inflated.—Foreign bodies more frequently slip into the right than the left bronchus.—The lymphatic glands situated at the origin of the bronchi are capable, when enlarged, of compressing somewhat the tubes and diminishing their calibre.—The pericardium and the left auricle must be placed among the indirect clinical relations of the left bronchus from the circumstance that diseases of the pericardium and of the left auricle may compress this structure. W. T. Gairdner⁴ has found numerous examples of bronchial obstruction followed by emphysema and pulmonary collapse.—For relations with Œsophagus see that structure.

Bloodvessels.—The *arteries* of the bronchial tubes are derived from the anterior bronchial branches of the internal mammary, and from the posterior bronchial arteries which arise from the aorta. The

branches last named may arise from the third intercostal arteries. The *veins* pass to the innominate veins and to the azygos vein. The *nerves* are derived from the inferior tracheal pneumogastric nerve.

THE LUNGS.

The Lungs are the organs of respiration. They occupy the greater part of the thoracic space, and are composed of a right and a left lung. Each lung may be said to be moulded to the shape of its own pleural cavity, and may be compared to a curve whose apex is directed upward, and whose base is directed downward. Each lung is again convex posteriorly, anteriorly, and at the lateral side; but is nearly flat on the median side, and is concave inferiorly. The base is inclined slightly downward and backward, so that it reaches a point farther down behind and at the lateral side than in front. A transverse section of the lung at its apex is nearly circular, oval in form; at its lower portions it is palm-shaped, the narrow portion of the figure being directed forward and the base backward.

The lung is everywhere free except at the region at which it is held in connection with the bronchial tubes and the pulmonary bloodvessels. These structures, together with the bronchial arteries, veins, nerves, and lymphatics, form a narrow pedicle, which is known as the *root of the lung*. The lung may be said to hang by its pedicle, as a fruit by its stem. The pleural fold which covers the lung pedicle and aids it in supporting the lung has received the name of the *ligamentum latum pulmonis*. The right lung-pedicle lies in front of the azygos vein, the left beneath the aortic arch, and partly in front of the descending portion of the aorta.

The lung presents for examination—

The Anterior Border.

The Posterior Border.

The Median Surface.

The Lateral Surface.

The Base.

The Apex.

The *anterior border* is compressed and presents an uneven contour. Upon the left lung this border is intended at its lower part for the accommodation of the heart.

The *posterior border* of the lung is nearly twice the length of the anterior. It is broad and massive, and is accommodated within the pulmonary groove of the thorax. It lies between the median and lateral surfaces; from the former it is separated by a well-defined line.

¹ Bredschneider, Casper's Wochenschr. 1842, 461.

² Boston Med. and Surg. Journ., 1861, Nov. 14.

³ Am. Journ. Med. Sci., li., 1866, 378.

⁴ Month. Journ. Med. Sci., Edinburgh, 1850, 122.

The two lungs are somewhat broadly contrasted. The right lung is the larger, including the right bronchus. It ascends higher in respiration, and succumbs easily to diseased action.

The shape of the lung is impressed to a slight and variable degree by adjacent structures. The subclavian artery, *infra*, may create a faint sulcus upon the anterior surface of the apex. The median side of the lung is rendered somewhat concave by the vena cava on the right side, and by the lower portion of the thoracic aorta on the left.

REMARKS.—The clinical remarks in connection with the anatomy of the lung may be embraced under the following heads: (a) the apex, (b) the root, (c) the base, and (d) the bronchial tubes.

(a) *The apex*.—The portion of the lung which is not confined by the thorax at the base of the neck is of course smaller in inspiration than in expiration. In robust individuals it is smaller than in those who are flat-chested.—The subclavian artery of each side passes over the front of the lung from one-half to one-third of an inch below the apex, and in some individuals creates a sulcus upon the lung surface.—The left upper lobe is shallower and narrower than the right. The result is that the percussion note above the clavicle is somewhat less resonant over the left than over the right upper lobe.¹—In phthisis the altered form of the chest modifies the mechanism of coughing. The abdominal muscles and the Diaphragm by their long-continued use become disproportionately powerful, and tend to force the lung upward in the thorax. J. Hamernjik² has called attention to the loss of elasticity of the lung in long-continued illness accompanied by cough; while Gruber³ has recorded several cases showing that, under the conditions above given, a cavity situated in the apex of the lung above the clavicle may be unable thoroughly to expel the contained air in expiration, or completely to discharge the liquid contents; and owing to the comparatively unprotected position of the apex, the walls of the cavity may project as a small triangular swelling at the base of the neck between the Sterno-Cleido-Mastoideus and the Anterior Scalene muscle.

(b) *The root*.—The root of the lung should be separated in clinical studies from the rest of the organ. Adhesions of any kind rarely occur here.—Lesions of the thoracic viscera not caused by the penetration of fractured ribs usually involve the lung and generally

occur near the root of the organ.¹—The left bronchus not only crosses the descending aorta and forms the lower limit, but it crosses the œsophagus as well. Both of these structures may excite diseased action at this place.—Owing to the fact that the aorta arches over the root of the left lung, this portion of the viscus is often compressed by aneurism of the aortic arch.

(c) *The base*.—The base of the lung is related clinically to the Diaphragm, the liver, and the spleen. It may be found adherent to the pleura of the Diaphragm, and may become involved in abdominal abscess which presses upward, and which may even open within the thoracic cavity, especially on the right side. Should the pleura of the base be adherent to the liver through the medium of the Diaphragm, such a collection may rupture within the lung-substance and be emptied through the bronchial tubes.

(d) *The bronchial tubes*.—The bronchial tubes may be constricted, as in asthma, from over-activity of the muscular fibres, or be over-dilated either through the inefficiency of these fibres or through degenerative processes in the remaining structures of their walls. The tubes, as they lie near or within the posterior mediastinum, are subject to compression from glandular, cancerous, aneurismal, and other growths, and may serve as conduits for blood and pus.

The lung may undergo congestion, partial collapse, and inflammation from the secondary effects of pressure by enlarged lymphatic glands (which are placed adjacent to the bronchial tubes) against the nerves of the pulmonary plexus.

W. Gull² narrates three cases of sloughing pneumonia following pressure against the pneumogastric nerves. J. P. Irvine³ has found that the left bronchus is especially liable to compression by mediastinal tumors, particularly by those lodged in the walls of the œsophagus. When the main bronchus of a lung is gradually obstructed by tumors originating beyond its boundaries, or by intra-mural fibroid changes, the act of expiration is impeded, and emphysema, lobar collapse, destructive pneumonia, etc. ensue.

THE PLEURÆ.

The Pleuræ are two closed serous sacs which line the spaces containing the lungs. Each pleural sac may be said to occupy the corresponding side of the thorax. The space between the sacs has received

¹ Sibson, *Med. Anat.*, Col. 37, 32.

² *Prager Vierteljahrschr.*, 1845, iii. 72.

³ *Vier Beiträge zur Med.-Chirurg. Anat.*, Berlin, 1847, 41.

¹ T. Holmes, *Surgical Diseases of Children*, 247.

² *Guy's Hosp. Reports*, 3d series, 1859, v. 309.

³ *Lancet*, 1878, pp. 415, 486, 563.

the name of the *mediastinum*. The left pleural sac, in consequence of the encroachment of the pericardium, is somewhat smaller than the right.

Each pleura may be said to present for examination a parietal and a pulmonic layer.

The *Parietal layer* is subdivided into a costal, a diaphragmatic, and a mediastinal portion.

The *costal portion* is the thickest of the three divisions, and covers the ribs and intercostal spaces.

The right costal pleura extends in front to the external end of the fifth rib, and covers in a considerable portion of the corresponding half of the sternum.

The *diaphragmatic portion* covers the Diaphragm. Between the root of the lung and the diaphragm extends a reflection of the pleura—the *ligamentum latum pulmonis*.

A small portion of the margin of the Diaphragm is not covered by the pleura, but is in direct contact with the wall of the thorax.

The *mediastinal portion* covers the median side of the lung, and is the most irregular of the divisions. It forms the lateral boundary of the several divisions of the mediastinum as it is defined from before backward. It covers the pericardium; and between the two passes the phrenic nerve. Anteriorly the mediastinal portion is in relation with the right internal mammary artery, and posteriorly, as it forms the side of the posterior mediastinum, it is in relation with the thoracic aorta and the œsophagus.

The pulmonary pleura is more adherent to the lung than is the parietal to the ribs; the diaphragmatic layer is also more adherent than the parietal.

The upper part of the right pleura terminates a little to the right of the median line of the sternum, and may even gain the left edge of the sternum. The left, on the contrary, may not reach further toward the median line than the first left costal cartilage.

The parietal *layer* covers the apex of the lung. It is here strengthened, according to Sibson, by a fascicle of the deep cervical fascia which extends from the transverse process of the last cervical vertebra to the inner border of the first rib.

The *Pulmonic layer* is thinner than the parietal, and is more translucent.

Beneath the costal and mediastinal portions a small layer of loose connective tissue is found, which is called the *subserous layer* (endo-thoracic fascia); it is but sparsely developed in the diaphragmatic and the pulmonic portions.

The right pleural sac, in addition to being the larger, is slightly shorter than the left. According to Luschka, it extends behind as far as the lower border of the ninth rib, while

the left pleural sac reaches to the lower border of the tenth rib.

Zuckerlandl¹ found the pleura receiving fibres of insertion of a muscle which is known as the *Scalenus Minimus*. This muscle is described as arising from the transverse processes of the sixth and seventh cervical vertebræ (or the latter only), or the upper border of the first rib, and is inserted into the top of the pleura. Quain (ii. 508) gives a similar reference to Sibson.

REMARKS.²—The superior *cul de-sac* is important from its relation to the subclavian artery. It is found in contact with the first rib for a distance of ten or twelve mm., and lies in contact with the subclavian artery from the region of the first intercostal space to the inferior cervical ganglion of the sympathetic and the anterior branch of the eighth cervical nerve.

During an operation for ligation of the right subclavian artery near its origin, Colles perforated the pleura with the aneurism needle. Bubbling of air in the wound and increased difficulty of respiration followed. Death occurred on the ninth day.

The following table is based upon a study of the extent of the pleura above the clavicles, including one hundred observations, by Dr. C. E. Isaacs:³—

The extent of the pleura above the clavicle in inches:—

	Right.	Left.
Sternal end,	1.19	0.95
Central portion,	1.42	1.23
Outer edge,	1.23	1.07

Lateral extent of the pleura above the clavicle:—

	Right.	Left.
Sternal edge from median line,	0.46	0.88
Outer edge from median line,	2.90	2.89
Width of pleura above clavicle,	2.88	2.01

In 14 cases it extended 2 in. above the clavicle.

In 5 cases it did not arise above the clavicle.

In 11 cases the inner edge of the pleura of the right side extended across and to the left of the median line.

The top of the pleural sac is not always dome-shaped, but sometimes forms *culs-de-sac* extending upward and sometimes laterally into the recesses at the root of the neck.

The subclavian artery in the third division of its course occasionally rests upon, or is in contact with, the pleura. This occurred in one case out of four.

¹ Zeit. für Anat. und Entwicklungsch., ii.

² The remarks and relations of the pleura to the ribs are treated of under one head.

³ Trans. N. Y. Acad., 1857, ii. 3.

The pleura rises high in the neck of long-necked people, and, on the contrary, is low in the short-necked, and especially in "bull-necked" subjects.

The parietal pleura, owing to the presence of connective tissue already mentioned, is but slightly affected by injuries of the ribs. Even after fracture of these bones the pleura often escapes. According to Riche, traumatic emphysema is not apt to occur except when adhesions exist between the lung and the pleura covering the broken rib.¹

Subpectoral abscess, axillary abscess, or tumor of the thoracic wall may involve the pleura through extension of the morbid process to the pleura by means of the subserous connective tissue.

The pleura, especially at the region of the thoracic aorta, the subclavian artery, and the œsophagus, will, by becoming greatly thickened in aneurismal and cancerous conditions, resist the invasion of diseased action; but when, by long-continued pressure, it suddenly yields, the fatal issue may be determined by copious hemorrhages into the pleural cavities, or by exciting acute inflammation therein of high grade.

In some cases of pleuritic effusion it is believed, by C. Ellis,² that the effusion instead of first collecting in the lowest part of the pleural sac, may, if small in quantity, occupy a conical portion of the pleural cavity in the sub-axillary region, under which conditions both normal resonance and the respiratory murmur may be wanting. In a certain number of cases where the effusion is quite large, if an accurate line be drawn, the flatness will be found to describe a curve gradually approaching the spine toward the base of the neck, leaving a space from one to three or more inches in breadth between the spine and the line of flatness. This is known as the curve of Darnoiseau, who described it in the *Revue Médicale* in 1843. Although a feature of pathological rather than of anatomical interest, its evident relation to some structural peculiarity in the juxtaposition of pleura and thoracic wall warrants its introduction at this place. Reference may be made, also, in connection with this subject, to some experiments performed by

G. M. Garland¹ in relation to the presence of fluid in the pleural cavities of the dog.

The pleura extends in the mammillary line to the sixth or the seventh cartilage. In the axillary line it extends to the lower border of the ninth rib on the right side, and to the tenth rib on the left.

Luschka estimates that the pleura does not pass downward to a point beyond the tenth rib. According to Holl,² however, it may reach the region of the twelfth rib. The pleura may be said to be longer than the lung by one inch. Hence it is possible for a perforating wound of the thoracic parietes to occur without injury to the lung.

THE MEDIASTINUM.

The interval between the right and left pleural sacs is called the mediastinum. It is arbitrarily divided into three compartments, a posterior, middle, and anterior, usually spoken of separately as the posterior, the middle, and the anterior mediastinum. For the relations of the structures contained in the mediastinum, the student is referred to the description of the several parts.

The *posterior mediastinum* is of an inverted pyramidal figure, the base lying at the superior thoracic aperture, and the apex at the Diaphragm. It is limited in front by the pericardium and the roots of the lungs, and is indented along its posterior margin by the forward projections of the bodies of the dorsal vertebræ.

The *posterior* mediastinum contains the œsophagus, the descending thoracic aorta, and a portion of the descending arch with the origins of the left common carotid and subclavian arteries, the azygos vein, pneumogastric nerves, the thoracic duct, and the thoracic lymphatic glands and sympathetic ganglia.

The connective tissue which unites these structures extends along the vertebral column upward to the prevertebral region of the neck, guided chiefly by the œsophagus, and downward along the sides of the aorta to the retroperitoneal space of the abdomen. From this peculiarity the pus of a cervical abscess can communicate with the posterior mediastinum, as the

¹ Anat. Med.-Chirurg., 557.

² Boston Med. and Surg. Journ., 1874, xc. 15.

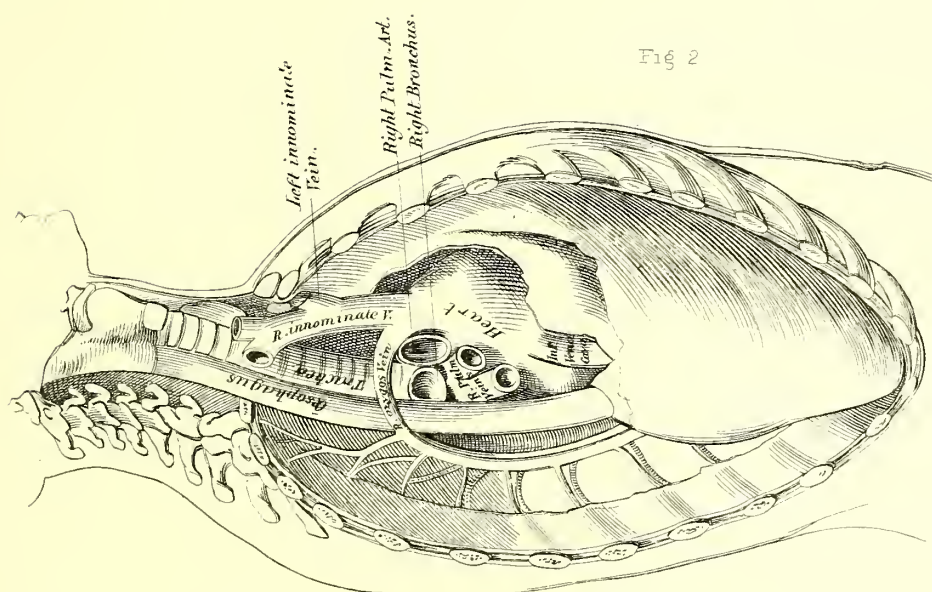
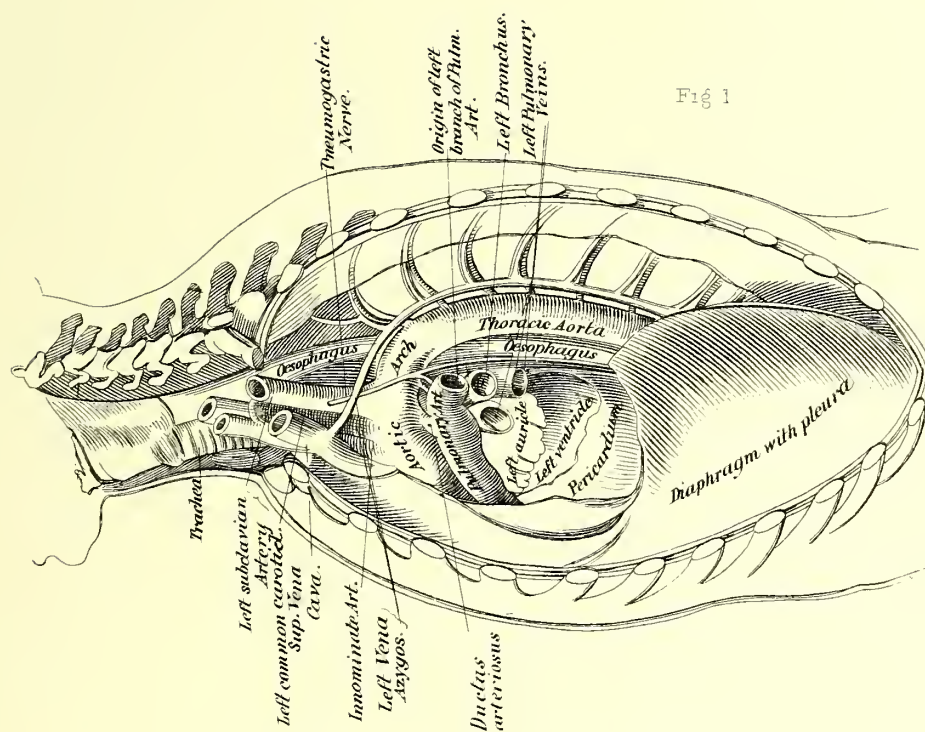
¹ Ibid., xci. 269.

² Archiv für klin. Chirurgie, xxv. 1880.

EXPLANATION OF PLATE CV.

Fig. 1. The relations of the parts within the interior of the thorax, seen from the left—the lung being removed.

Fig. 2. The same, seen from the right.



pus of a thoracic abscess may penetrate the abdomen. In like manner the blood escaping from a ruptured aneurism of the abdominal aorta may involve the posterior mediastinum. Ordinarily, the position of the bifurcation of the trachea limits the ascent or descent of fluid. Thus, a clot from the abdomen will reach to the line of tracheal bifurcation from below, while one from the neck, or upper part of the mediastinal space, will reach it from above.

Mr. Bristowe¹ has described an aneurism of the abdominal aorta, just above the celiac axis, which in bursting caused blood to pass into the posterior mediastinum. The clot was confined to the lower half of the space.

Abscesses dependent upon caries of the vertebræ are found along the outer portions of the mediastinum, and the sheath-like connective tissue surrounding the region of the intercostal arteries and veins.

The *middle* mediastinum answers to the space containing the pericardium and its contents.

The space between the two pleural sacs contains the heart, the great arterial trunks at their origin, and the terminal portions of the great veins. The space is widest at its middle third, and abruptly diminishes in size above the heart.

The *anterior* mediastinum, as defined by English authors, is the interval between the sternum and the pericardium. All of the sub-manubrial connective tissue may without error be included in it according to continental writers, who speak of the anterior mediastinum as the space containing the connective tissue lying beneath the entire length of the sternum. It follows the inclination of the heart, being inclined from right to left. It is broader below than above. It is narrowest opposite the upper portion of the gladiolus, where, indeed, the two pleuræ may touch.

The anterior mediastinum contains, in addition to the connective tissue already mentioned, a small quantity of fat at its lower portion, the thymus gland in the infant and its remains in the adult, and the origin of the Sterno-Hyoid and Sterno-Thyroid muscles as well as of the Triangularis Sterni and of the left internal mammary artery.

REMARKS.—The clinical study of the mediastinum embraces for the most part the anterior and the posterior portions. The anterior portion is a common site for development of sarcomatous tumors, and the posterior portion for cancerous tumors.² The posterior portion again, from the circumstance that it is

in communication with the retroperitoneal space by the connective tissue and with the aortic and œsophageal orifices, may become involved secondarily by many diseased processes which have their origin in the lower portion of the trunk. The pus from a peri-nephritic abscess may thus pass upward into the posterior mediastinum.—The abdominal portions of the œsophagus, of the aorta, and of the thoracic duct may be the sites of the initial processes of disease which involve the thoracic portions secondarily.

THE GENITO-URINARY ORGANS.

The Genito-Urinary Organs embrace

The Kidney.

The Bladder.

The Male Organs of Generation.

The Female Organs of Generation.

THE KIDNEYS.

The Kidneys are the principal organs of excretion. They are two flattened, elongated, bean-shaped bodies situated in the lumbar regions, in front of the last two dorsal and first two lumbar vertebræ, the right kidney being a little lower than the left, owing to the position of the liver. The average length of each kidney is about four-and-a-half inches, its width two inches, and its thickness one-and-a-quarter inch. Its weight is from four to six ounces.

The kidney is supplied by the renal artery, which enters the gland at a notch upon its inner side, where also, occupying a position behind the vessels, the ureter escapes. This notch has received the name of the *hilum*. Its posterior lip is less pronounced than the anterior, thus permitting the ureter to be exposed behind for a greater distance than in front. Extending from the hilum within the kidney are a chamber termed the *sinus*, containing some fat, and the subdivisions of the structures at the hilum. The anterior surface of the kidney is more convex than the posterior, and the lower extremity is slightly thicker and broader than the upper. The kidneys are not in the plane of a vertical section made from side to side, but are inclined to that plane in such wise that the outer margin of each is posterior, and the inner margin is anterior. Neither are they parallel to the vertebral column, since their upper extremities are slightly inclined toward each other.

A longitudinal section of the kidney exhibits a cortical and a medullary portion. The cortical is of a darker color than the medullary portion; both por-

¹ Trans. Path. Soc. Lond., x. 88.

² E. T. Bruen, Phila. Med. Times, 1884.

tions are obscurely striated, an appearance best seen in the medullary. The cortical is not separated by any sharply defined line from the medullary portion, since here and there minute processes pass down a short distance into the medullary region, constituting the so-called columns of Bertini.¹

The *color* of the kidney is a dark reddish-brown, externally. In *consistence* the organ is the most dense and also the most friable of the glands of the body. When moderately compressed the tissue breaks transversely. Each kidney is embraced by a capsule of thin fibrous tissue, containing elastic fibres. This covering is easily stripped from the normal organ, being attached to it only by small bloodvessels and minute connective tissue fibres. In certain pathological conditions, however, it becomes tightly adherent.

Relations.—Surrounding the kidney is a quantity of delicate adipose tissue, which is often called the fatty capsule (*tunica adiposa*). Behind, the kidney rests upon the lumbar fascia in great part, projecting slightly beyond its outer border, and to its inner side lying upon the psoas fascia, which in connection with the psoas muscle separates it from the vertebral column, and the crus of the Diaphragm, in front of the eleventh and twelfth ribs. It thus overlies the twelfth dorsal nerve as well as the transverse branches of the lumbar nerves. In front is the peritoneum, the relations varying on the two sides. Each kidney is surmounted by the corresponding supra-renal capsule. The right kidney lies behind the descending portion of the duodenum, the ascending colon, and sometimes the gall-bladder. The left lies behind the descending colon, which when contracted is placed to one side. The left kidney also possesses indirect relations in front with the spleen, the pancreas, and the stomach. In addition to this, the right kidney is in contact with a slight depression upon the under surface of the liver.—The lower extremity of the kidney is nearly in contact with the crest of the ilium. According to Holden, the kidney is opposite the two lower dorsal and two upper lumbar spines. The pelvis lies about on the level of the first lumbar vertebra. The upper border of the kidney is on the level of the interspace between the eleventh and the twelfth

dorsal vertebræ. The lower border may reach a point as low as the third lumbar spine.—During deep inspiration both kidneys are depressed slightly.—The kidney can be palpated below the last rib at the outer edge of the Erector Spinae muscle.

The medullary portion is composed of from ten to fifteen pyramidal masses (pyramids of Malpighi), whose bases are external, and whose apices project

Fig. 189.

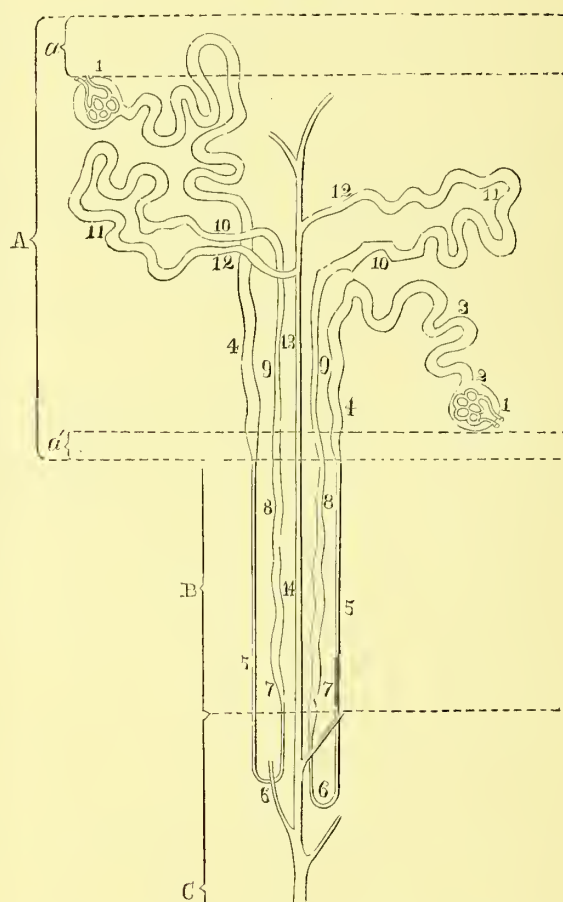


Diagram showing the course of the uriniferous tubules in the different parts of the cortex and medulla. A. Cortex limited on its free surface by the capsule; *a*, subcapsular layer not containing Malpighian corpuscles; *a'*, inner stratum of cortex without Malpighian corpuscles; *b*, boundary layer; *c*, papillary part next the boundary layer; 1, Bowman's capsule; 2, neck of capsule; 3, proximal convoluted tube; 4, spiral part; 5, descending limb of Henle's loop-tube; 6, the loop itself; 7, 8, and 9, the ascending limb of Henle's loop-tube; 10, the irregular tubule; 11, the distal convoluted tubule; 12, the first part of the collecting tube; 13 and 14, larger collecting tube; in the papilla itself, not represented here, the collecting tube joins others, and forms the duct.

¹ These are absent in edentates, bats, apes, and some carnivorous animals, by reason of the confluence of the bases of the pyramids.

EXPLANATION OF PLATE CVI.

Fig. 1. The relations of the parts within the thorax, seen from in front, the anterior wall of the thorax, the lungs, and the heart in position.

Fig. 2. The same, seen from behind. The posterior wall of the thorax is removed, and the lungs pressed aside.

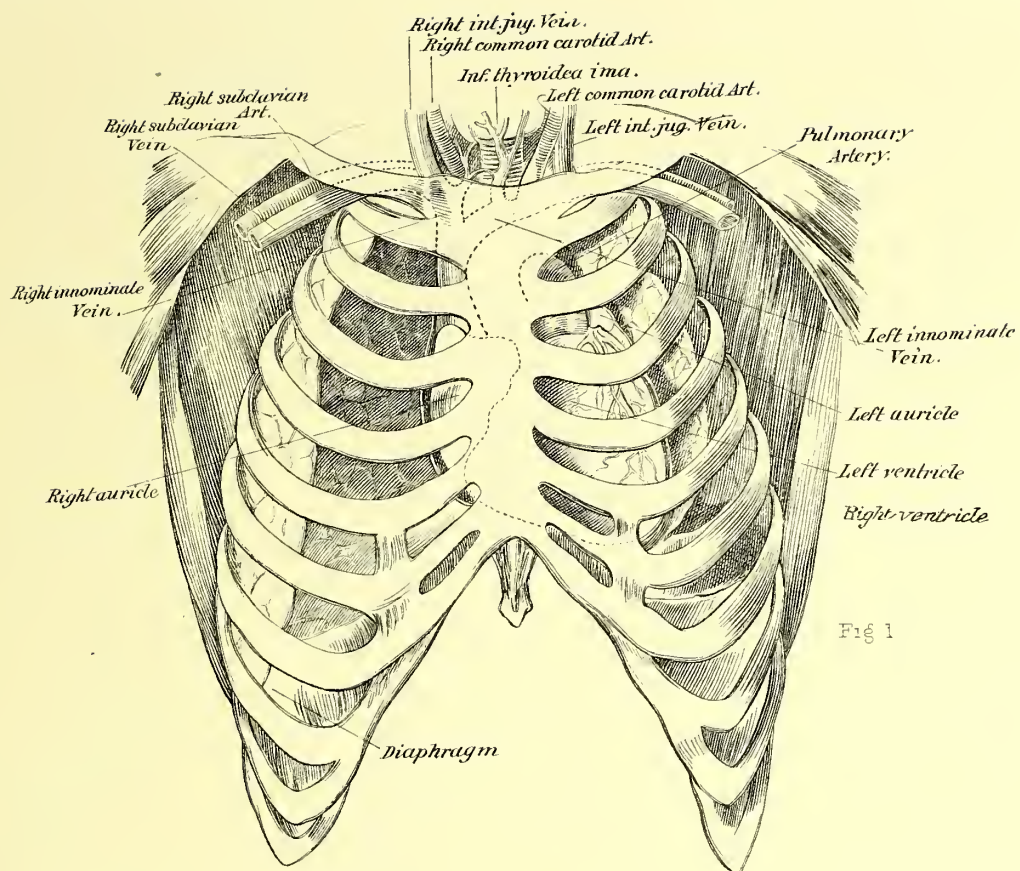


Fig. 1

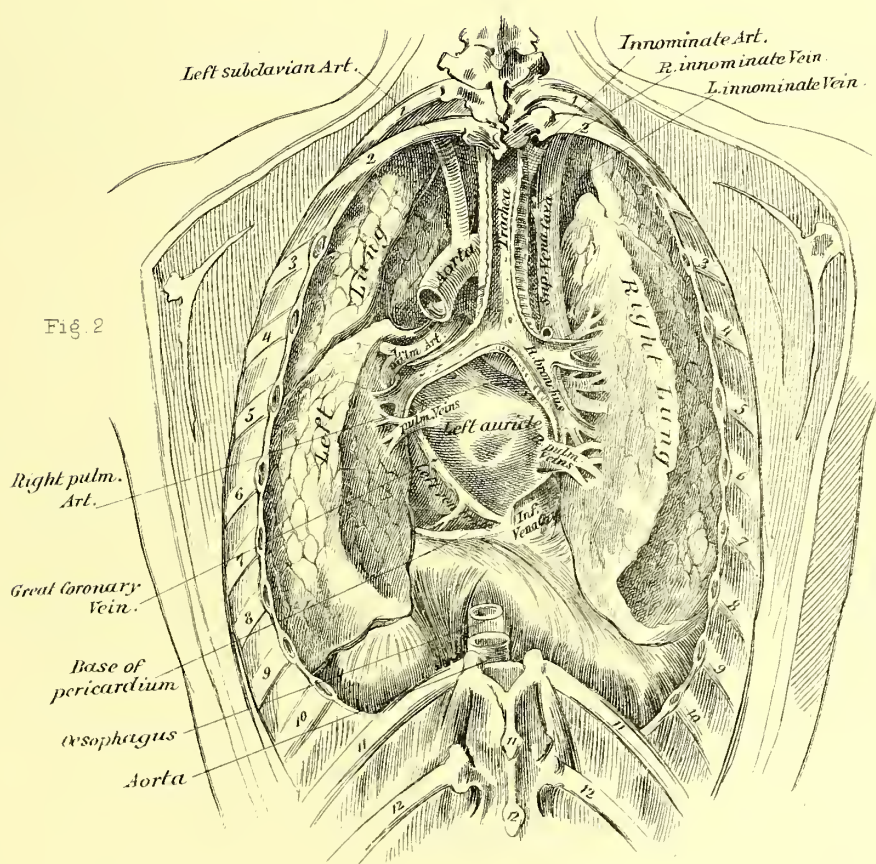
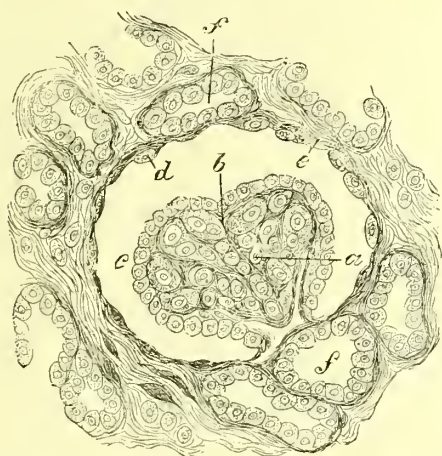


Fig. 2

into the pelvis, where they constitute the *renal papillæ*. Each pyramid is of a grayish tint, except at the papilla, where it is of a purplish-red. Each papilla is pierced by numbers of minute orifices, representing the termination of the excretory tubules (*q. v.*).

Minute structure.—The kidney is an association of tubular convoluted glands,—a pyramid representing a convergent group of closely related bundles of *uriniferous tubules* whose origin is in the cortex. The real divisions of the kidney structure, therefore, are not those of cortex and medulla, notwithstanding the apparent value of this distinction, but are between the pyramids or groups of the tubules; for it is between these that the arteries, nerves, and connective tissue secure access to the tubules, and by these in part that the veins and lymphatics escape; while in the foetal kidney distinct lobulations are limited by the cellular interspaces.

Fig. 190.



From a section through the cortical substance of the kidney of a human foetus, showing a Malpighian corpuscle. *a*, glomerulus; *b*, tissue of the glomerulus; *c*, epithelium covering the glomerulus; *d*, flattened epithelium lining Bowman's capsule; *e*, the capsule itself; *f*, uriniferous tubules in cross section.

A *uriniferous tubule* arises within the cortex by a bulbous expansion about a small rounded tuft made up of arteries and veins, the whole, vessels and envelope, being called a *Malpighian corpuscle*, which will be described under the head of the bloodvessels. The expansion of the tubule is called *Bowman's capsule*; the tuft of vessels, the *Malpighian tuft* or *glomerulus*. The tubule, as it leaves the glomerulus, becomes abruptly constricted, forming the *neck* of the Malpighian corpuscle, afterwards becoming tortuous, constituting the *tubuli contorti*. Farther on most of the tubules are observed to become contracted and to form long loops, the *loops of Henle*, which extend through the boundary layer to the margin of or even into the papillary portion of the medulla, and, returning to the cortex, again become widened and tortuous before emptying into the *straight tubules* (*tubuli rectæ*). Thence they pass directly inward to the pyramids of Malpighi. The lower portions of the

uriniferous tubules present a diameter varying from $\frac{1}{240}$ th to $\frac{1}{30}$ th of an inch, the convoluted tubes and the smaller straight tubes, $\frac{1}{60}$ th of an inch.

The raceme-like clusters of the Malpighian tufts and the tortuous origin and termination of the looped tubules give the characteristic expression to the cortex. When these parts are not aggregated near the superficies of the organ, but are diffused through the kidney, as is the case in birds and reptiles, no cortical portion exists. The groups of tufts and tortuous tubules form elongated masses broader without than within, and thus enable the straight tubes leaving the convoluted ones at the inner extremity of a cluster to enter the pyramids of Malpighi, while those at its upper portion will pursue a course almost equal to the entire thickness of the cortex before entering the pyramid.

Fig. 191.

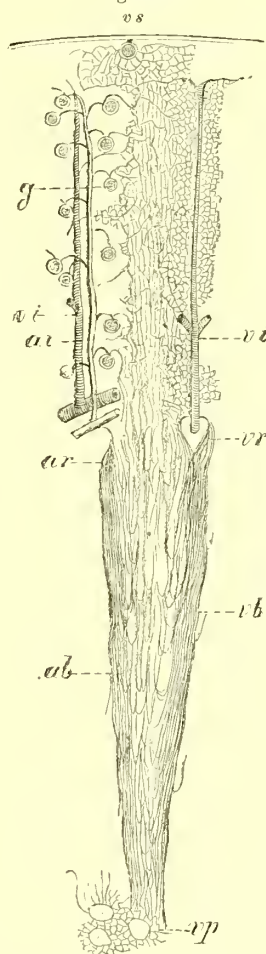


Diagram of the vessels of the kidney. *ai*, Interlobular artery; *vi*, interlobular vein; *g*, glomerulus of Malpighian corpuscle; *vs*, vena stellata; *ar*, arteria recta; *vr*, vena recta; *ab*, bundle of arteria recta; *vb*, bundle of vena recta; *vp*, network of vessels around the mouth of the ducts at the apex of the papilla.

The collection of straight tubes between the groups of tufts and their convoluted tubules has received the name of the *pyramid of Ferrein*, *pyramidal process*, or *medullary rays*. Several of these correspond to the base of a

single Malpighian pyramid. They differ from the Malpighian pyramids by having their bases within and by being confined largely to the cortex. The central tubules in the former are parallel, while those in the pyramids of Malpighi are acutely convergent.

The epithelium in the straight tubes is columnar; in the other portions of the tubules the character of the cells is often obscured by their granular contents—the cells varying in shape from the scales lining the capsule to the low-columnar and cuboidal forms of the convoluted tubes, in certain parts of which a striation of the peripheral parts of the cells is described.

The Bloodvessels.—As already mentioned, the arteries of the kidney enter at the hilum, subdivide in the sinus, and the resultant twigs pass between the pyramids of Malpighi to their bases. They here form an imperfect anastomosis termed the *interlobular arch*, from which small arteries the interlobular arteries ascend to the cortex between the pyramids of Ferrein. From these interlobular arteries arise lateral stems, each bearing rounded berry-like knots of capillaries covered by a membranous envelope (the Malpighian corpuscles). Each of these presents a diameter ranging from the $\frac{1}{120}$ th to the $\frac{1}{270}$ th of an inch. The artery entering the corpuscle is called the *afferent* vessel, and the vein leaving it the *efferent* or *emulgent* vessel. The latter is somewhat smaller than the former, and soon breaks up into a network of veins which ramify among the uriniferous tubules, becoming elongated among the straight tubes, and forming at the bases of the pyramids an anastomosis termed the *interlobular veins*. From these arise the veins of exit which pass from the gland to the veins of the sinus. Upon the cortex some of the smaller venules terminate in *stellate veins*, which in some degenerative conditions form conspicuous objects on the surface of the kidney. Each vein is composed of from five to six branches whose extremities are lost in the intertubal network.

Upon the papillæ a delicate venous network is seen having an arrangement somewhat different from that between the tubes, with which, however, it is continuous.

It will be seen that the network lying between the emulgent veins of the Malpighian tufts and the renal vein is comparable to the hepatic network intervening between the portal and hepatic veins, and has sometimes received the name of the portal network of the kidney. Ludwig and Zawarykin¹ have shown that the supply of the kidney is not in all respects dependent upon the renal artery, since a partial injection of the kidney of a dog was effected after tying the renal artery.

The *lymphatics* of the kidney are of two sets, a superficial and a deep, which freely anastomose.

The connective-tissue stroma is poorly developed in the adult kidney. It extends between the tubules and the bloodvessels, and is more marked in the

immediate vicinity of the Malpighian corpuscle than elsewhere in the cortex; but on the whole the connective tissue reaches the highest development in the papillary portion of the medulla. Its scanty presence may serve to explain the fragility of the organ.

Variations.—The kidney may vary in position from the one assigned as normal. The organ may be occasionally movable from one of two causes, either from the organ being enveloped in peritoneum when a true meso-nephron exists, or from the absorption of fat from about the kidney.

The kidney may be divided transversely, each division possessing a separate ureter. There may be more than two kidneys on each side, imperfectly joined. Double ureters may exist with an otherwise normal kidney.—The union of the two kidneys is ordinarily accomplished by an isthmus of crescentic outline, joining the lower borders, the concavity being directed upward. Such malformations are known as *fused* or *horse-shoe kidneys*. According to R. P. Harris,¹ this term has also been given to a single kidney of an unusually curved form. In a specimen of fused kidney exhibited before the Pathological Society of Philadelphia² by Thos. G. Morton, the greater part of the mass was situated upon the left side of the vertebral column, the concave edge presented downward, and the hilum was situated upon the lateral border.

After an elaborate study of the recorded cases of misplaced and movable kidney, A. E. Durham³ has arrived at the following conclusions: "Fixed misplacement of the kidneys is usually congenital, as is indicated, among other considerations, by the corresponding irregularities presented by the renal bloodvessels. The left kidney is more liable to fixed displacement than the right; and its misplacement is usually associated with malposition of the colon. The right kidney is more frequently movable than the left. Women are more liable to the affection than are men."

The kidney may be placed lower than is normal, being found as far down as the crest of the ilium, or even within the cavity of the true pelvis. Congenital misplacements of the kidney are commonly met with. The position of the renal vessels should be carefully observed in dissection of these subjects. Hyrtl affirms that, if the vessels have their normal relations to the great trunks, the malposition is acquired. If, however, they be shown to be abnormal, the malposition is congenital. A congenital pelvic kidney may receive its blood from the aorta and the common iliac artery.

The kidney may be absent on one side. The remaining organ is then termed *single* or *solitary* kidney. Drs. Willard, Packard, and Reed⁴ found that out of twenty-one cases, references to which are given, the left kidney was absent in

¹ Proc. of the Path. Soc. of Phil., 1860, 81.

² Loc. cit., p. 77.

³ Guy's Hospital Rep., 1860, iv. 420.

⁴ Proceedings Pathological Society of Philadelphia, 1870, 172.

¹ Wiener Acad. Sitzungsbericht, xlviii. 1864.

seventeen, the right in four. The kidney at birth contains crystals of urate of soda.—The detection of such crystals has no value in forensic medicine, since they are by no means confined to the fetal gland, but may be found as late as the forty-fourth day.¹—The absence of one kidney may be associated with anomalies of the sexual apparatus. O. Beumer² found as a result of an analysis of forty-eight cases that one-half were in males.

REMARKS.—A correct impression of the relations of the kidney is often important in interpreting the effects of lesions in the loins. Thus, from the fragility of the organ, rupture of the gland substance may follow indirect violence. The clot of blood which forms after such accidents lies between the kidney and the peritoneum anteriorly, and has been known to form a tumor of sufficient size to press against the colon and to interfere with the passage of the feces. It is hardly possible that the colon should altogether escape severe local pressure from the fact that it overlies and is close to the injured renal organ.³

The relations of the right kidney to the liver may determine the site of pain in nephritis by the descent of the liver in inspiration, as suggested by Cruveilhier. The organ may be pushed downward by an enlarged liver.⁴

The extensive communications of the connective tissue about the organ with remote points determine the directions which pus may take in suppurative peri-nephritis. Thus the pus may pass downward along the course of the Psoas muscle (*q. v.*), and appear at the groin; or upward between the pillars of the Diaphragm, where it may cause adhesions to form between the layers of the pleura; or may penetrate the pleural cavity and even empty into the bronchial tubes.

In a case recorded by Renard,⁵ a penetrating gunshot wound of the trunk involved the right kidney and caused a urinary fistule to be established through the wound of exit. An abscess subsequently formed within the right lung which communicated by several openings through the Diaphragm with the upper portion of the kidney. The patient survived ninety days. According to A. B. Duffin,⁶ the position of the thigh in peri-nephritic abscess differs from that seen in

psoas abscess in the circumstance that the pelvis is tilted “up to the utmost in peri-nephritic abscess in order to relax the lumbar fold.”

THE EXCRETORY APPARATUS.

The Excretory Apparatus of the kidney begins by numbers of membranous tubes which embrace the papillæ and secure attachment to the free projecting portions of the pyramids. These have received the name of the *lesser calices*. They quickly unite to form two or three separate convergent portions, the *greater calices* (infundibula), and these terminate in a pouch-shaped expansion of the ureter, termed the *pelvis* of the kidney. The remaining portion of the excretory channel, namely, that lying between the pelvis and the bladder, constitutes the *ureter*.

The Ureter is a membranous tube from fourteen to eighteen inches in length, extending downward and inward, so as to lie obliquely across the psoas fascia. At the margin of the true pelvis the ureter crosses the origin of the common iliac vessels, at times on the right side the origin of the external iliac artery only.

The spermatic vessels lie in front of the ureter, and, near its termination in the male, the vas deferens lies to the inner side. The right ureter lies close to the outer side of the inferior vena cava.

The ureter, as it lies within the pelvis, is four-and-three-quarters inches (twelve cm.) long. The left ureter crosses the left common iliac artery about three-quarters of an inch (one-and-a-half cm.) above its termination, and is a little nearer the median line than is the right.

Within the true pelvis the ureters rapidly converge and narrow in calibre till they enter obliquely the inferior portion of the posterior surface of the bladder, each by a small slit-like orifice from one-and-a-half to two inches from its fellow.

The oblique direction of the ureter through the wall of the bladder has the effect of a valve in preventing regurgitation of urine from the bladder.

In the female the ureter at the last portion of its course lies between the neck of the uterus and the bladder, and hence that portion engaged within the walls of the last-named structure is liable to be compressed by the neck of the uterus. Luschka affirms that in pregnancy a physiological dilatation of the ureters results from this relation.

Structure.—The minute structure of the ureter shows an external fibrous layer, a middle layer of longitudinal and circular muscular fibres, and an inner or

¹ J. Hodann, Vierteljahrsschrift für gerichtl. und öffentl. Medecin, 1855, 33.

² Virchow's Archiv, 1878, 344.

³ Jno. Hilton, Guy's Hosp. Reports, 1867, 17.

⁴ Rayer, Traité des Mal. des Reins, 799.

⁵ Gaz. des Hôpitaux, 1861, 202.

⁶ Trans. Path. Soc. Lond., 1873, 138.

mucons layer. The epithelium is of the stratified transitional type.

Variations.—The variations of the ureter are unimportant. The ureter may be double; very rarely three ureters pass out from a normal kidney.

REMARKS.—Compression of the ureters in cancer of the uterus often results in their enormous dilatation.—In obstruction to the outflow of the urine, either from stricture or disease of the bladder, the valvular character of the cysto-uretral orifice is destroyed, and the ureter becomes dilated.—Velpéau¹ mentions a case in which a pin, lodged in the colon, had penetrated the ureter, and had collected upon its free projecting portion a quantity of calculous matter. It is thus possible for foreign bodies, which may have effected entrance into the ureter or the bladder from the intestinal canal, to serve as nuclei for calculus.

In marked examples of dilatation, such as occur from occlusion by pressure, the ureter may assume a spiral form a short distance from the kidney, so that a valvular arrangement results which is of itself sufficient to prevent the escape of urine from the pelvis of the kidney.²

Lushka³ enters into a careful study of the relations, anatomical and clinical, of the ureter in the female. The following is an abridgment: The right ureter lies at first behind the end of the descending portion of the duodenum, so that these organs may communicate abnormally. The left ureter descends behind the duodeno-jejunal flexure; it may effect an abnormal communication with the sigmoid flexure.

In a woman aged twenty-nine years, coming under the author's observation, it was noticed that, after recovery from pelvic cellulitis, a swelling developed in the left iliac region, near its junction with the lumbar region. A urinary fistule was established which discharged urine and feces. No bladder symptoms were present, and the urine which escaped was perfectly normal. It was thought that

a fistulous communication had been established between the left ureter and the sigmoid flexure. The patient recovered.

In deviation of the pregnant uterus from the median line to the right side, owing to malposition of the rectum, the right ureter is apt to be compressed. The pelvic portion is in part surrounded by the peritoneum, and in part by parametritic venous plexuses, which spread out from near the supra-vaginal portion of the uterine neck, the base of the broad ligament, and the vaginal vault.

At the base of the broad ligaments, the ureters are applied to the pelvic wall, the left to the inner side, the right to the outer side of the internal iliac artery of the corresponding side.—After leaving the lateral wall of the pelvis, each ureter crosses the round ligament and pierces the venous plexus at the side of the vagina and the neck of the uterus, where it is in relation with the uterine artery. The ureter forms a faint sigmoid curve near the supra-vaginal portion of the cervix, and finally approaches to within about five-eighths of an inch (one-and-a-half cm.) of the anterior wall of the vagina, and crosses the lateral surface of this passage at an acute angle. The proximity of the ureter to the vagina increases as the former passes downward and inward toward the median line at the bladder. At the level of the internal os the ureter is one inch (two-and-a-half cm.) distant. At the supra-vaginal portion it lies three inches and three lines (eight cm.) from the vagina, and at the vault of the vagina two and three-eighths inches (six cm.). Thus retroflexion of the uterus may give rise to pressure upon the ureter.—In pronounced distension of the bladder the ureters are closely approximated to the anterior wall of the vagina. When the bladder is contracted the peritoneum not only covers in the anterior wall of the entire supra-vaginal portion of the cervix, but also overlies the vault of the vagina, a thin layer of subperitoneal connective tissue alone intervening. This tissue, while the bladder is distended, lies between that organ and the uterus.

An excellent example of a fistule connecting the ureter with the uterus is described by Freund.¹ At the autopsy the left ureter as it approached the cervix

¹ Anat. Chir., ii. 175.

² Chas. J. Hare, Med. Times and Gaz., xiv. 1857, 233.

³ Archiv f. Gynäkologie, iii. Heft 3, Taf. ix.

¹ Klin. Beiträge zur Gynäcolog. Heft 1, 108, No. 14.

EXPLANATION OF PLATE CVII.

Fig. 1. A diagrammatic representation of the kidney, seen in a vertical transverse (frontal) section.

Fig. 2. The bladder bisected, so as to display the fundus.

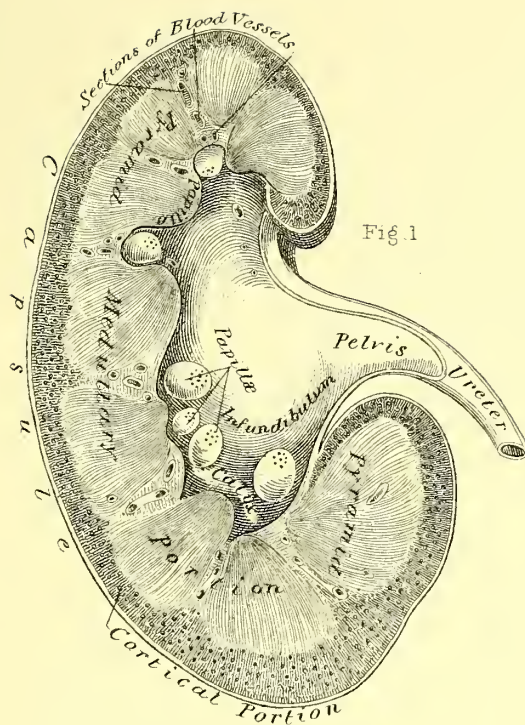
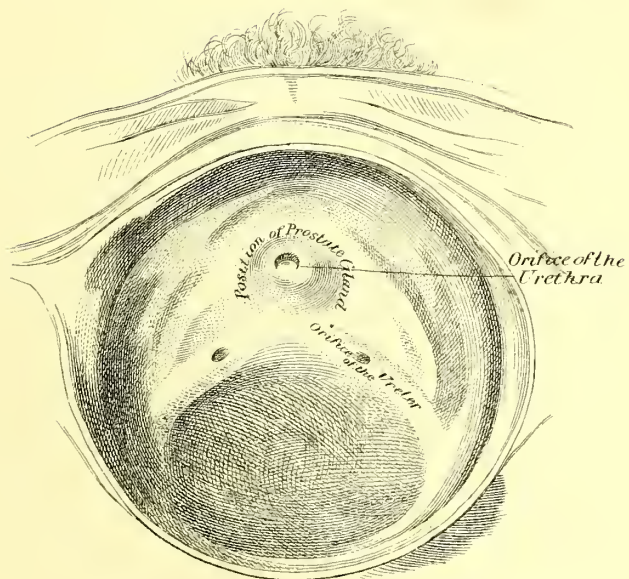


Fig. 2



uteri was found surrounded by indurated connective tissue. Within this mass was an ill-defined cavity into which the ureter opened, and connecting this cavity with the canal of the cervix was a canal of the fineness of a hair; above the ureter was dilated.

A hydatid tumor may compress the ureter within the pelvis. Mr. Murchison¹ describes a cyst lying behind the uterus and forcing this viscus down so as to cause it to appear at the vulva. Another smaller cyst was found in the same subject lying at the right side of the pelvis. The ureters were compressed, and the pelves of the kidneys slightly dilated. The kidneys were small and granular.

With respect to the lesions of the ureter A. Poland² presents the following excellent summary:—

“The only vulnerable parts of the ureter are its commencement at the pelvis of the kidney, and the first few inches of its course. Here it is situated in the loin, and may undergo stretching from inordinate torsion of the body, or may be exposed to external violence from severe contusions in this region. Hence in all cases recorded, injury to the ureter has been found close to the kidney. The ureter may be ruptured by severe contusions without lesion of any other important structure, the escape of the urine into the cellular tissue behind the peritoneum inducing peritonitis. This condition may be complicated with lesion of the kidneys and other important structures. The ureter has also been injured by penetrating wounds, and may be obliterated by diseased action.”

The ureter is so intimately united with the tissues involved in ovarian and uterine disease that it may be opened or ruptured in ovariectomy and related operations. Such an accident occurred to Simon, who cured the urinary fistule thereby established by excision of the corresponding kidney. Von Nussbaum relieved a similar condition by defleeting the fistulous tract into the summit of the bladder.³

THE BLADDER.

The Bladder (fig. 2, Plate LXXIV.; fig. 2, Plate CVII.; figs. 3 and 4, Plate CVIII.; fig. 3, Plate CIX.; and Figs. 194 and 195) is the reservoir for urine. It is an elliptical or egg-shaped sac projected from the front of the genito-urinary tract between the termination of the ureters and the origin of the urethra.

Its capacity varies greatly, but may be said to range from six to thirteen ounces. It has been fre-

quently asserted that the bladder of the female is larger than that of the male. While it is true that with some females the bladder may be larger, it is now believed that the average capacity of the female bladder is actually less than that of the male.

The longest diameter of the bladder is vertical, namely, from the base to the summit. The greatest transverse diameter of the bladder in the female is three-fourths of an inch to one and one-fifth inch above the internal orifice of the urethra.⁴

The posterior surface is more convex than the anterior, and the entire viscus is somewhat compressed from side to side. When seen from before the bladder is of a triangular shape. It is reasonable to suppose that in the living state the weight of the intestine must tend to flatten the summit and in part the posterior wall.—When empty the bladder of the female is collapsed, the sides and summit are in contact, and on section the cavity presents the appearance of a mere chink.

The bladder is divided topographically into the summit, the sides, and the base, and presents an anterior and a posterior surface.

The *summit* (superior fundus) is rounded, covered with peritoneum, and continuous with the cord representing the remains of the urachus, which ascends as far as the umbilicus. The *lateral surfaces* (sides) are in contact with the true lateral ligaments derived from the recto-vesical fascia. In common with the preceeding they are covered with peritoneum.

The *base* (inferior fundus, bas-fond) is directed toward the perineum, and is in relation with the rectum of the male, and the neck of the uterus and vagina in the female. The former relation is confined to a small triangular space having the vas deferens and vesiculæ seminales at the sides, and the prostate gland in front. The *cervix* or *neck* of the bladder is a term used to signify the region directly behind the internal urethral orifice.—The *anterior surface* projects a short distance above the pubis, but is not covered with peritoneum. It forms an angle with the base at the urethral orifice. In front are the pubis and a delicate layer of fat.—The *posterior surface* of the bladder is continuous with the base.

In addition to the relations of the peritoneum already noted, there remain to be mentioned the folds of that membrane which extend from the bladder to associated parts. These are five in number, and are known as the *false ligaments of the bladder*.

¹ Diseases of the Liver, 109.

² Guy's Hosp. Rep., 1868, 85.

³ Aerztliches Intell.-Blatt, 1876, Nos. 7 and 8. Trans. in Ed. Med. Journ., 1876, July 1.

⁴ Pansch, Archiv f. Anat. u. Phys., 1874, 702.

The *superior* ligament lies between the hypogastric arteries, and extends from the summit of the bladder to the umbilicus.

The two *lateral* ligaments extend from the sides of the pelvis to the walls of the bladder.

The two *posterior* ligaments (recto-vesical) extend from the rectum to the sides of the bladder.

Under the name of the *true ligaments* may be mentioned processes of the pelvic fascia situated at the sides of the bladder. These are four in number, two anterior and two lateral. The two *anterior ligaments* (pubo-prostatic) extend from the symphysis pubis to the front of the bladder and the prostate gland. Each contains a small muscular slip from the bladder. The *lateral ligaments*, one on either side of the bladder, extend from the pelvic fascia covering the Levator Ani muscle to the prostate gland and the bladder.

The internal surface of the bladder is smooth, when the organ is filled with urine, but wrinkled when empty, excepting at its base, which is at all times nearly smooth. The basal surface (trigone) corresponds to the triangular interval between the urethral and urethral orifices.

In the female this space is smaller than in the male by reason of the absence of the prostate gland.

At the urethral orifice is a slight median elevation known as the *uvula vesicæ* (lurette). When the bladder is empty the position of this portion of the base is marked by a few longitudinal plications, and extending across between the urethral orifices is a faint inconstant elevation, due to the muscular coat.

The connective tissue beneath the mucous membrane is abundant, and beneath it in turn is the muscular coat.

The *muscular* coat is composed of three layers, the *longitudinal* layer (external layer), which is best developed upon the anterior and posterior surfaces; the *circular* layer, which being well defined at the neck (Sphincter Vesicæ) becomes weaker, above and behind than in front, and its fibres are more or less decussating near the summit; and a *submucous* layer (internal layer), which is composed of delicate longitudinal fibres, and is best developed at the summit of the bladder.—According to Juric,¹ the longitudinal fibres are so related to the sphincter that when the former contract the sphincter is pulled open.

The epithelium of the bladder is composed of small rounded cells, from among which pyriform cells arise

by their small ends, and bearing upon their swollen ends large capitate cells, which are larger than those of the deeper layers. Thus the ureters and bladder are possessed of an epithelial lining similar in character.

Relations.—The position of the bladder can be determined by the finger in the rectum, at which point the surgeon can detect that portion of the angle which forms the apex of the trigone. This is the spot, according to Holden,¹ at which the distended bladder should be punctured through the rectum.

J. G. Garson² has written an extended account of the alterations of the position of the bladder due to distension of the rectum.

Variations.—Ectrophy of the bladder is that condition in which the anterior wall as well as the corresponding portion of the abdominal parietes is absent. The posterior wall of the bladder is thus exposed, and brought nearly to the level of the anterior contour of the trunk. The orifices of the ureters are of course exposed.

The umbilical termination of the urachus may be patulous in the infant, permitting urine to escape. The urethra may be closed in some examples of persistent urachus, or where tight congenital phimosis exists, the urine in either case escaping entirely by the umbilicus. More frequently both are pervious, the greater portion of the urine being voided by the urethra.³ The urachus when patulous may become cystiform. C. E. E. Hoffmann⁴ describes a striking instance of this variety, in which four separate tappings of the sac were instituted, each being followed by the escape of large quantities of fluid. After death the bladder was found contracted, and the urachus closed at its vesical end, while its middle portion was enormously distended, thickened, and lined with pavement epithelium.⁵

According to Luschka,⁶ the urachus is essentially a hollow tube. Observers have occasionally found calculi lodged within this canal.

REMARKS.—The bladder possesses a tendency to sacculation. A variable portion of the wall may be thus depressed, and afford favorite sites for the deposition of calculi.

In some rare instances, the sacculations which occur at the side of the bladder may become ingredients of an inguinal hernia, or scrotal hernia,⁷ or assume various abnormal positions. In a case mentioned by C. Mur-

¹ Landmarks, p. 76.

² Edin. Med. Journ., 1878, xxiv. 300.

³ Guéniot, Bulletin de Thérap., Oct. 1872.

⁴ Archiv f. Heilkunde, 1870, 373.

⁵ For a *résumé* of the subject of persistent urachus, see A. Rose, N. Y. Med. Rec., xii. 516.

⁶ Virchow's Archiv., 1862, xxiii. 1; also Luschka's Anatomie, 229.

⁷ G. Pileher, Trans. Path. Soc. London, 1853, iv. 187.

¹ Stricker's Hdbuch., iv. 1873.

chison,¹ the sacculated portion extended within the abdomen as far as Poupart's ligament, where it pressed upon the femoral vein, and excited inflammation of its walls.

An ovarian or other tumor growing upward from the pelvis is liable to carry with it the upper portion of the bladder, and compress it against the abdominal wall. Median incisions in the hypogastric region in such cases should be guardedly made, since the thinned and emptied viscus can with difficulty be distinguished from surrounding tissues.

Rupture and distension of the bladder, while strictly surgical subjects, present some underlying anatomical features which may be here briefly epitomized: when distension occurs as the result of a slow process, the walls of the bladder become thinned, and an interstitial spontaneous rupture may occur which will be confined to the muscular and mucous layers—a pouch defined by peritoneum receiving the urine. This pouch is generally upon the posterior surface as a natural result of the absence of that support which the anterior surface, and in part the lateral surfaces, receive from the abdominal walls, as well as from the fact that at the sides the peritoneum is tense and comparatively unyielding. For similar reasons the posterior wall is most liable to be ruptured after violence. Nevertheless, in many cases the site of the lesion holds a fixed relation to the direction of the force. This force may rupture all the coats of the viscus. Following such an accident upon the anterior surface, the urine will escape into the sub-peritoneal connective tissue of the abdominal wall (*q. v.*). The rupture occurring inferiorly will cause the urine to infiltrate the perineum, provided the recto-vesical fascia has yielded; and posteriorly it will cause the urine to flow into the peritoneal cavity. Rupture from beneath is liable to be associated with laceration of the urethra (*q. v.*), this canal being made tense by the upward inclination of the distended bladder. Thus the bladder may be ruptured from a kick in the perineum. Erskine Mason² describes this accident as occurring in a boy. The bladder was ruptured at the side near the neck, and the urethra was lacerated. In an interesting accident reported by Mr. Thompson,³ the laceration was incurred by the patient falling on his back from a height of twenty feet, and a heavy mass of earth directly afterward crushing the abdomen. The bladder was found ruptured, and the perineum lacerated. The

external wound was sufficiently large to permit three fingers to be passed with ease through it into the bladder. The observer, in commenting upon the case, concludes: "It is evident that the weight and pressure of the earth compressed the bladder so completely within the pelvis, that the urine was sent forward with such force as to tear the urethra and the perineum."

Thomas D. Jones⁴ reports a curious example of closure of the opening in a ruptured bladder by a portion of bowel.

In the female, rupture of the bladder, according to Harrison, is rare, for the following reasons:—

"The viscus does not incline backward to the degree seen in the male, but enlarges forward and in the transverse direction. The uterus and its lateral folds assist in breaking the shock of any external violence applied to the hypogastric region, and to prevent the direct concussion of the bladder against the promontory of the sacrum."

Distended bladder naturally displaces the uterus upward and backward, and may thus act as a factor in preventing contraction of the uterus after delivery. Geo. T. Elliot² includes this condition among the causes of post-partum hemorrhage.

Inflammations of and extravasations into the tissues of the pelvis of women lead more frequently to the evacuation of the products of diseased action through the bladder than in men.³

The contraction of the muscular coat of the bladder has a direct influence in closing the ureters and preventing regurgitation during the emptying of the viscus.⁴

THE PROSTATE GLAND.

The Prostate Gland (prostate body) is a collection of racemose glands surrounded by a firm symmetrical musculo-cellular stroma. It embraces the urethra from the neck of the bladder to the triangular ligament, a distance of one and one-eighth to one and one-fourth inches, at the same time receiving the utricule and the ejaculatory ducts.

It lies immediately in front of the rectum at about its middle third, at which point it can be readily felt. The gland resembles in outline a truncated cone, and presents a base and an apex, as well as anterior, posterior, and lateral surfaces.

¹ Trans. Path. Soc. Lond., xiv., 1863, 133.

² N. Y. Med. Journ., 1874, 638.

³ Prov. Med. and Surg. Journ., Oct. 20, 1851.

¹ Lancet, Aug. 20, 1870, 252.

² N. Y. Med. Journal, April, 1867, 35.

³ Ibid., 41.

⁴ Jurie, Stricker's Med. Jahrbücher, 1873, iv.

The *base* is notched in the median line for the entrance of the urethra; in advance of this is a single funnel-shaped depression for the ejaculatory ducts.

The *apex* is adherent to the triangular ligament, and is surrounded by the anterior fasciculi of the Levator Ani muscle.

The anterior and posterior surfaces are broader than the lateral, and are but slightly convex. The *anterior surface* is in contact with the pubo-prostatic ligaments—median and lateral—and with the connective tissue behind the symphysis pubis. The *posterior surface* is separated from the rectum by the prostatico-peritoneal aponeurosis, or recto-vesical fascia. The *lateral surfaces* are convex, and the posterior form with the posterior notch two more or less pronounced masses which slightly diverge. These are the *lateral lobes* of the prostate.

The points of union of the lateral portions at the floor of the urethra, both in front and behind the orifices of the ejaculatory ducts, form two transverse connecting tracts which H. Thompson proposes to designate as the *anterior* and the *posterior commissures*. The anterior commissure is always inconspicuous, and never seen without first stripping off the mucous membrane. It is poor in gland tissue—some writers, indeed, as Thompson and Jarjavay, denying its existence. The posterior commissure, on the other hand, is rich in glands and is noted as the site of frequent enlargement, being then denominated the *middle lobe*. Since it is of importance to employ a correct terminology in describing a locality which is so often the seat of hypertrophy, Thompson has suggested that it be termed the *median portion*, the so-called *middle lobe* being simply an outgrowth of prostatic tissue at that point.

Development.—A proper understanding of the prostatic lobes demands a knowledge of the origin of the entire organ. Up to the fourth month of intrauterine development the prostate gland is represented by a pair of oval bodies, one on either side of the urethra. These subsequently unite in great part, but leave, in the *lateral lobes*, evidence of the original symmetrical duplicature of the organ.

Measurements.—The prostate gland measures in the young healthy adult about one-and-three-quarters in width, and seven lines in thickness. In consequence of its truncated form, the base exceeds by a fourth or a fifth the measure of the longitudinal axis. It weighs from four to six drachms.

Structure.—On section the gland is seen to be yellowish-white or reddish-gray in color. The *glands* are not seen at a superficial inspection, but require to be studied carefully with the microscope. They are from twenty to thirty in number, and belong, as already mentioned, to the racemose type. They differ, however, from the salivary and duodenal glands, examples of the same type, in having the secreting follicles relatively few in number and irregularly

disposed. The orifices of the glands open about the outer sides of the orifices of the ejaculatory ducts.

According to W. Soetlin, it would appear that the prostate is a conglomerate gland, the gland being tubular, not racemose.¹

The *stroma* makes up the bulk of the body. It is composed of a fibroid tissue containing some elastic fibres, among which are placed unstriated muscular fibres. The latter form two sets of fibres; a longitudinal and a circular set. The *longitudinal* lie immediately beneath the mucous membrane and are continuous with the sub-urethral muscle elsewhere described. The *circular* fibres are more thinly disposed than the preceding, but become thicker posteriorly, where they are traceable into the circular layer of the muscular coat of the bladder. These form at the neck of that viscus, the Sphincter Vesicæ. According to Pettigrew, the circular fibres belong to figure-of-8-like loops, the complements of which are to be seen in the walls of the bladder.

The urethra as it passes through the prostate gland receives the name of the *prostatic portion*. It will be fully described under the head of the Urethra. In connection with this, it may be stated, however, that the greater portion of the prostate lies behind the urethra, and that the ejaculatory ducts (see Testicle), pierce the post-urethral portion obliquely upward and forward, to open on either side of the orifice of the *utricle*.

The prostate gland is surrounded by a proper capsule or fascia which adheres intimately to the stroma. Embracing it in common with other pelvic viscera are portions of the pelvic fascia. As this lies around the gland it is separated at the sides and particularly in front by the prostatic plexus of veins.

Relations.—The prostate gland lies about one-and-a-half or two inches above the anus. Within the bladder the shape of the gland can be measurably defined even in health. In many diseased conditions the tendency exists for the gland to project within the bladder and to form an obstructive growth which will arrest the flow of urine from the bladder.

The Bloodvessels of the prostate gland.—The arteries are derived from the inferior vesical and middle hæmorrhoidal arteries. An artery may be found running between the capsule and the ileo-vesical reflection of fascia. The prostatic veins open into the prostatic plexus, and are generally seen filled with coagula, and in old persons are occupied here and there by phleboliths. It is from this plexus that the venous hemorrhage in the operation of lithotomy is derived. According to Valentine Mott,² the bleeding

¹ Centralbl. f. d. Med. Wissenschaften, No. 22, 1871.

² N. Y. Journ. of Med., 1858, 319.

resulting from cutting through the plexus in the operation of lithotomy is slight. Secondary hemorrhage may be, however, alarming in amount in patients of middle age—the veins emitting an enormous quantity of blood.

Variations.—The prostate is rudimentary in instances of unusual development of the masculine uterus. (See Teratology.)

REMARKS.—The prostate gland is cut through in the perineal operation for lithotomy. The organ is susceptible of a peculiar hypertrophy which is announced about the forty-fifth year.—Tubercular and gonorrhoeal abscesses are not infrequent.

THE PENIS.

The Penis (figs. 3, 4, Plate CVIII.) is the organ of copulation. It is an erectile, symmetrical structure, and accommodates that portion of the urethra which lies in advance of the membranous portion. In the undissected subject, the part which lies in advance of the scrotum and is covered with integument is known as the *pendulous portion*. The *deep portion* of the penis (root, sub-pubic portion) lies in the sub-pubic space.—The skin-covering of the pendulous portion is remarkable for its thinness, for the absence of subcutaneous fat, and for the loose attachments to adjacent structures. The integument serves to cover in the anterior extremity, or glans penis, by a cap-like duplicature (prepuce), the outer surface of which is cutaneous, the inner (where it is applied to the glans) mucous-dermic. The layer last named is held firmly to the body of the penis at a point of constriction (neck of the penis), which is found directly behind the glans, whence it is traceable over the glans to the urethra, with the mucous membrane of which it is continuous.

When erected the penis is subcylindrical in form.—The pendulous and deep portions are composed of three distinct structures, namely, a pair of cavernous bodies (*corpora cavernosa*) and a median spongy body (*corpus spongiosum*).

Each Cavernous Body arises from the inner lip of the descending ramus of the pubis, and a portion of the ascending ramus of the ischium passes forward toward the median line to unite with its fellow of the opposite side at about the level of the top of the sub-pubic arch. Each body is fusiform, though the portion between its origin and union with its fellow is somewhat swollen and constitutes the *crus*. After the union of the crura these bodies, together with the corresponding portion of the spongy body, compose the *body* or *shaft* of the penis.

Both cavernous bodies are abruptly acuminate at the anterior free end, and are received within the posterior concave surface of the glans.

The cavernous bodies, as conjoined, present a faint groove above for the dorsal vein, and beneath a wider groove for the spongy body. Surrounding the cavernous bodies is a dense *sheath* composed of fibrous tissue intermingled with elastic filaments.

The greater portion of the sheath is composed of a layer of longitudinal filaments which surround the cavernous bodies. Beneath this is a second layer, composed of circular filaments. The septum is a partition of similar filaments well developed posteriorly, but presents the appearance of an irregular open network (septum pectiniforme) anteriorly. From the septum numerous fibrous bands (trabeculae) extend outward, which intersect among themselves, and which define a number of spaces lined with squamous endothelium, constituting the erectile tissue of the cavernous bodies. A number of delicate nerves and unstriated muscle-fibres lie along the trabeculae. The intervening network is occupied by the terminal twigs of vessels and capillaries.

Bloodvessels.—The arteries of the cavernous body are derived from the internal pudic,—each cavernous body receiving in addition deep branches from the dorsal artery of the penis. The branches and more superficial twigs terminate in delicate spiral arterioles from the extremities of which the capillaries take their origin. These arterioles have received the name of the *helicine arteries* of J. Müller.

The *veins* of the cavernous bodies are tributary to the pudendal plexus and to the internal pudic vein.

Nerves.—The nerves form a plexus within the cavernous bodies, and are derived from the hypogastric plexus.

Lymphatics.—The lymphatics join the hypogastric lymphatic glands.

The Spongy Body is a modified cylindrical figure lying at first in the space between the converging crura of the cavernous bodies, and beyond this point in the groove beneath these conjoined structures. At the extremity of the penis it terminates abruptly in an expanded extremity, the *glans penis*, to receive the ends of the cavernous bodies. The glans penis is obliquely truncate from below upward and backward, and ends in a thickened rounded edge—the *corona glandis*.

The spongy body is swollen behind to constitute the *bulb* which is in contact with the triangular ligament. The spongy body surrounded by the Bulbo-

Cavernosus musculus is contracted between the bulb and the glans penis, and yields at the base of the corona a number of follicular glands (glands of Tyson), which secrete a semi-solid substance, known as *smegma*.—The spongy body resembles the cavernous in essential features. The fibrous investing tissue is weaker than in the former organ, and the trabeculae less noticeable.

The bulb in the young subject exhibits a slight tendency to become bi-lobed.

Bloodvessels.—The arrangement of the *arteries* of the spongy body is of the same character as that seen in the cavernous bodies. The branches of the internal pudic have sometimes received the names of the bulbo-urethral and the bulbo-cavernosus arteries.

The glans penis receives, in addition to the bulbo-cavernosus artery, a separate branch from the dorsal artery of the penis.

Veins.—The veins of the penis chiefly pass out through the deep parts of the organ, particularly through the bulb of the spongy body and the back part of the cavernous bodies. Others effect exit between the cavernous bodies and the spongy body, and, passing upward along the sides of the organ, join the dorsal vein. The dorsal vein of the penis receives much of its blood from about the anterior portion of the spongy body. Tributary veins to the dorsal vein also pass upward from the sides of the spongy body.

Nerves.—The nerves are derived from the hypogastric plexus, as well as the pudic. The terminal twigs upon the glans bear Pacinian corpuscles.

Lymphatics.—The lymphatics of the spongy body are abundant, and lie beneath the covering of the glans and prepuce, as well as beneath the mucous membrane of the urethra. The superficial vessels are received by the inguinal glands, while the deeper ones empty into the hypogastric ganglia.

Variations.—The glans may be cleft so as to form two distinct portions, the meatus of the urethra appearing at the base of the fissure; the prepuce may be absent or may be

congenitally adherent to the glans penis, and the smegma be mechanically retained in the partially obliterated preputial chamber. When the urethra terminates at a point on the under surface of the organ back of the glans penis, the condition known as *hypospadias* is said to exist. Hypospadias should be studied together with malposition of the testicles and with development of the utricle. When the urethra is open above, *epispadias* is said to exist, a condition which should be studied with ectrophy of the bladder. The utricle may be of large size, a condition which is, as a rule, associated with hypospadias.—The utricle may extend a short distance behind the bladder, or it may pass up well into the pelvis and occupy the position of the uterus in the female. The pouch is easily determined by the position of the vasa deferentia, which should open into it. The prostate body in cases of hypospadias is rudimentary.

REMARKS. — Owing to the loose connective tissue about the penis the organ is susceptible of great swelling when acutely inflamed. Extravasation of blood may occur in the same position, and even gangrene of the integument ensue.—The integument of the penis is appropriated by swellings and growths originating in the scrotum. Under these conditions the penis appears to be retracted, and almost lost within the contour of the tumefied scrotum.

The cavernous bodies, when rigid by erection, are liable to lesion, especially to "fracture," which is complicated with great extravasation of blood.—Instances are known in which the entire cavernous bodies have sloughed away. Mr. Gay¹ has reported an instance of gangrene of both the cavernous and spongy bodies.—The spongy body retains an intimate association with the urethra. Urethritis when of high grade involves the spongy body; abscess of the spongy body is occasionally noticed as a sequel. From the fact that the spongy body is slightly shorter than the cavernous bodies, the penis when erected is moderately curved. The curve is exaggerated in erections associated with inflammatory stasis and infiltrations within the spongy bodies.

¹ Tr. Path. Soc. Lond., 1878; see also Archiv f. clin. Surg., 1879, 5.

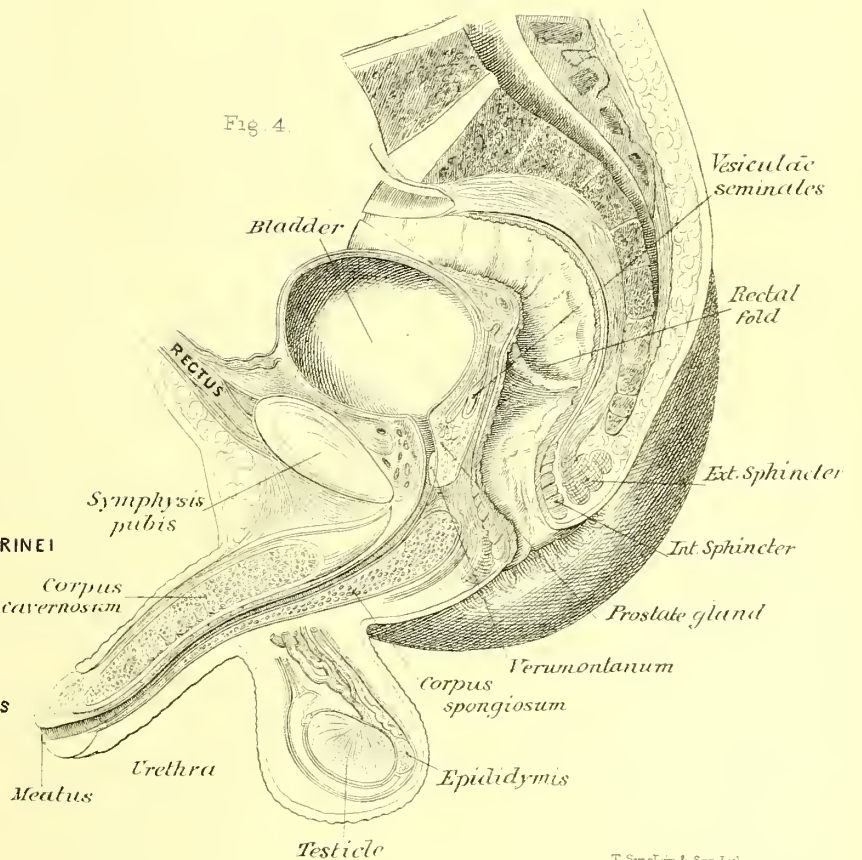
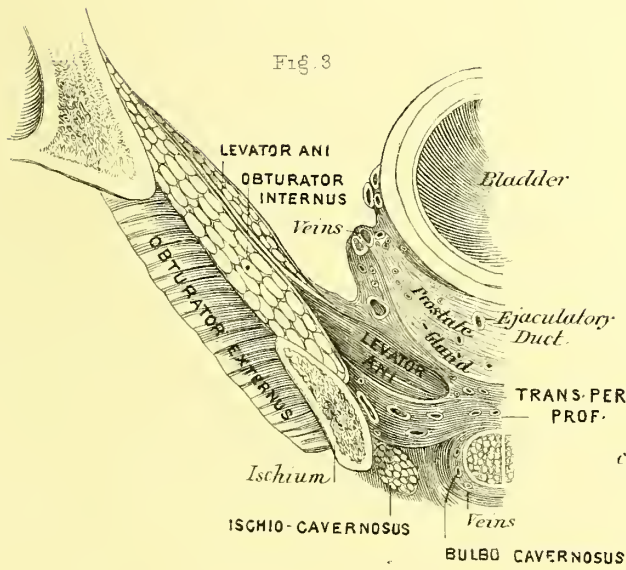
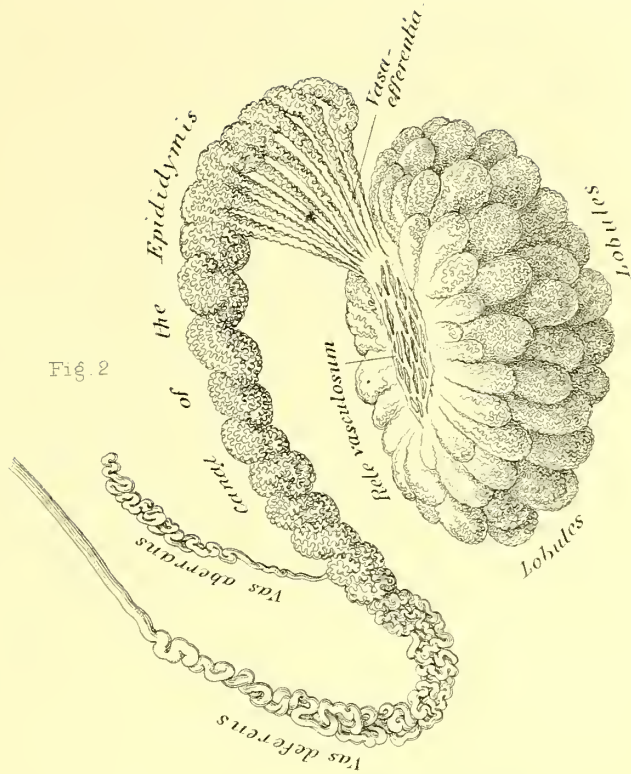
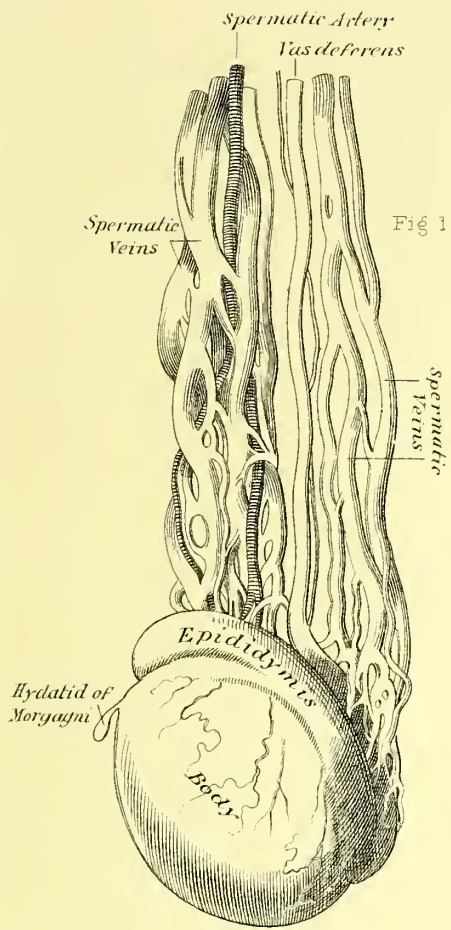
EXPLANATION OF PLATE CVIII.

Fig. 1. The testicle with its duct and vessels in position in the spermatic cord.

Fig. 2. A diagrammatic representation of the testicle displayed on the plan of injection.

Fig. 3. A sinistro-dextral (frontal) section of the right half of the male perineum.

Fig. 4. An antero-posterior (longitudinal) section of the male pelvis and the organs of generation.



THE URETHRA OF THE MALE.

The Urethra is that portion of the genito-urinary tract extending from the bladder outward. The internal orifice is known as the internal meatus or vesical orifice; the external orifice as the cutaneous orifice or external meatus.

The Urethra, when the penis is at rest, describes an *s*-like curve; the portion at the right end of the figure corresponds roughly to the pendulous division of the penis, and is known as the *spongy portion* of the urethra; the portion at the left end of the figure represents the *membranous* and *prostatic* portions. The length of the urethra is about six inches, of which the membranous and prostatic portions represent each one inch, the remaining four inches pertaining to the spongy portion, and when the penis is erected it is slightly longer upon its anterior than its posterior surface.

The *prostatic portion* lies between the bladder and the triangular ligament. It measures one-and-an-eighth to one-and-a-half inches in length. It is from one-fourth to one-third of an inch wide at its widest part, and gradually tapers thence to both the anterior and the posterior end. The prostatic portion is surrounded, as the name expresses, by the prostate gland, a layer of longitudinal muscle-fibres alone intervening.

The floor of the prostatic portion of the urethra is marked by a conspicuous elevation called the *veru montanum* (caput gallinaginis, calliculus seminalis, urethral crest), which begins at the base of the bladder and terminates somewhat abruptly at the middle of the prostatic portion. It measures eight to nine lines in length by one-and-a-half lines in height, and is marked in the centre by an oval depression which is one-third to one-half of a line in width, and which constitutes the mouth of the utricle.—The *utricle* (uterus masculinus, sinus pocularis, pouch of Weber) is a flask-shaped chamber which measures two-and-a-half to six lines in length, and from two to three lines wide. The utricle is held to be the homologue of the uterus, and in some animals is large, and is used as a reservoir for spermatic filaments. The lateral margin of the utricle receives the ejaculatory ducts; or the ducts may empty into the depressions at the sides. Surrounding the veru montanum are the orifices of the prostatic follicles.

The *membranous portion* lies between the two layers of the triangular ligament, about one inch below the pubic arch. It is in consequence the least extensible of any of the three portions of the urethra.

It is nine lines in length on the anterior surface, and six in length on the posterior surface. The diameter of the canal at the proximal end of the membranous portion is six lines, and at its distal end five-tenths of a line.

The membranous portion is embraced by the Deep Perineal muscles,¹ and is sometimes known as the cavernous portion.—The circular fibres are well developed.² The mucous membrane is plicated, but is without glands.

The *spongy portion* is surrounded by a cavernous submucous layer, which is more abundant at the region of the bulbous portion of the spongy body than elsewhere. This layer is succeeded by a thin layer of circular fibres, which in turn is embraced by the spongy body proper. The spongy portion widens at the region of the bulb to form the *sinus bulbi*, and presents, from that point to a point near the region of the glans penis, a calibre of about one-and-a-half line, when it expands a second time to form the *navicular fossa* beyond which it again contracts to terminate at the meatus urinarius.

The *mucous membrane of the urethra* is covered with columnar epithelium, except a tract about an inch or an inch and a half from the meatus, where it is covered with squamous epithelium. In the tract just named, a number of papillæ are present.

The mucous membrane of the urethra is thin and intimately associated with the submucous tissues. The membrane is plicated when not distended by urine or the seminal fluid.

The spongy portion is furnished with a number of minute racemose glands which have received the name of glands of Littre.

The upper surface of this portion of the canal presents several pockets which open forward and are termed the *lacunæ*. They are found sparse at the side and occasionally beneath.

Cowper's Glands.—The most important appendages to the spongy portion of the urethra are Cowper's glands (sub-urethral glands). These are glands of the racemose type, of about the size of peas, and are placed one on each side of the membranous portion, between the layers of the triangular ligament and

¹ P. 328.

² Luschka describes a *Sphincter Urethrae muscle* which is composed, according to Henle, of some irregular fibres of the Deep Transverse Perineal unconnected with the raphé or with the *pubo-ischiatic ligament*. These fasciculi are striated, and should not be confounded with the non-striated true circular fibres.

imbedded among the fibres of the Deep Transverse Perineal muscle. Each of the ducts is an inch long, and passes forward to open into the spongy portion at the bulb. The secretion of Cowper's glands lubricates the urethra with a viscid fluid after micturition. It may also contribute to the seminal fluid.

REMARKS.—The urethra can be divided for practical purposes as follows: (a) the pendulous portion, (b) the membranous portion, (c) the prostatic portion.

(a) *The pendulous portion.*—The clinical history of this portion is for the most part that of the urethra and also that of the spongy body. The lacunæ are often the sites at which a foreign body or a calculus may lodge. They may be also the seats of localized inflammation.

(b) *The membranous portion* of the urethra can be felt through the front wall of the rectum, when an instrument occupies the urethra. In the child the urethra is relatively smaller than it is in the adult. Peri-urethral abscess of this portion of the urethra is a not infrequent sequel of gonorrhœa. The effects of urethral stricture are here most noticeable.

C. E. Isaacs¹ found in a subject examined by him a sac, lined with epithelium resembling that of the urethra and bladder, capable of holding an ounce of fluid, and extending backward and upward from the membranous portion of the urethra between the bladder and the rectum as far as the reflection of the peritoneum. This sac communicated with the cavity of the abdomen by an orifice two lines in width. The peritoneum in the neighborhood was acutely inflamed.

When the bladder is distended, the viscus tends to ascend into the abdominal cavity, while the prostatic and membranous portions of the urethra become stretched and tense. In this condition of the parts, external violence, as blows on the perineum or fracture of the pubic bone, is liable to tear the membranous portion of the urethra transversely, or the incautious introduction of a bougie or catheter (particularly if it be of small calibre) may easily create a false passage. Such a rupture always occurs beneath the symphysis pubis close to the prostate gland. The lining membrane may be divided while the outer coat escapes.

(c) *The prostatic portion.*—The clinical interest here relates chiefly to the conditions of the bladder. The prostatic portion is compressed and distorted in hypertrophy of the prostate gland. It is opened by the knife in the perineal operation for lithotomy.

J. Hilton¹ has found that a careful study of escaped urethral clots is of value in the diagnosis of urethral affections which are accompanied with hemorrhage.

THE TESTICLE.

The Testicle is the organ which produces the spermatogenic filaments. It is composed of the testicle proper, or body, and the epididymis. It is a flattened egg-shaped body, whose long axis is directed obliquely upward and outward, and the upper end inclined forward.

The upper end of the testicle is covered with the head of the epididymis, its inner border by the remainder of that structure and the origin of the vas deferens. The remaining surfaces are covered by the tunica vaginalis.

The testicle measures one and-a-half to two inches in length, one in width, one-and-a-quarter antero-posteriorly.² It weighs from four to seven drachms.

The main covering of the testicle is called the *tunica albuginea*. It is composed of pure fibrous tissue, and measures half a line in thickness. The tunica albuginea is evenly distributed, but receives a marked accession in thickness beneath the head of the epididymis where it is projected into the parenchyma of the testis. The point of reflection is termed the *mediastinum testis*, and is usually described as though it were a reflection of the tunica albuginea. It is composed, however, of all the structures passing in or out of the testicle; viz.: Tunica albuginea, the pampiniform plexus of veins, and the arteries. It is of a prismatic form, and of a spongy consistence. It is situated at the upper end of the internal border. From its lower portion numerous minute diverging layers of fibrous tissue (trabeculae) pass into the testis, and serve as imperfect septa between the spaces which lodge the proper gland-substance.

The inner layer of the tunica albuginea is covered with a delicate network of bloodvessels (*tunica vasculosa*, *pia mater testis*), which extends along the trabeculae.

The epididymis is a portion of the excretory apparatus of the testicle which terminates in the vas deferens. It is of an elongated figure, situated at the upper end and internal border of the body of the testicle. The upper end, the head or *globus major*, is rounded in section, while the lower part, the tail or *globus minor*, as well as the intermediate portion,

¹ Guy's Hosp. Rep., 1867, 9.

² The size of the testicle differs at different times. Slight variation in size Henle attributes to the condition of the connective tissue stroma.

¹ N. Y. Journ. of Med., July, 1858, 1.

is somewhat prismoidal, the anterior edge being the thinnest. The lower surface of the epididymis is either flat or slightly concave, while the upper surface is convex. It is covered by a membrane analogous to the tunica albuginea, but much thinner.

Structure.—The testicle is composed of a soft parenchyma (pulp of the testicle), which is of a dull white or yellowish color. The parenchyma is composed of a number of lobules, which are variously estimated to be from two hundred to four hundred in number. According to Lauth, they may reach eight hundred and forty. The number of lobules varies in different individuals, and at times a large lobule is composed of two or three smaller ones. Each lobule is of an elongated conical figure, with the base outward and the apex inward. It is supported above and below by the trabeculae of the tunica albuginea. Each lobule is composed of ramifications of a system of delicate tubes known as the *seminal tubules*. Formerly it was supposed that the lobules were simple but highly convoluted follicles; but it is now thought that they more frequently terminate by anastomosis; some authors denying that they ever end in blind extremities. The lobules are themselves united here and there by anastomotic tubules. The tubules found in a single lobule number from one to three, which finally terminate in a single straight duct. The series of the straight ducts constitute the *vasa recta* of Haller. They are about twenty in number; each possesses a diameter of one-sixtieth to one-seventieth of an inch upward and backward. They place the tunica albuginea toward the inner border of the testicle, and enter a close-meshed network of tubules, termed the *rete testis* (plexus reteformis). It is through the meshes of this network that the bloodvessels pass to and from the gland. The ducts leading from this plexus are termed the *vasa efferentia*. These are from six to twenty in number, and measure from five to eight lines in length. They pass upward and backward, some becoming convoluted to terminate in the epididymis. The thick conical distal end of the convoluted tubes has received the name of *coni vasculosi*.

The minute anatomy of the tubules varies according to the locality. In the body of the testicle they are from $\frac{1}{200}$ to $\frac{1}{50}$ of an inch in diameter, and are lined with layers of delicate but irregular epithelium, which serves as a nidus for the development of spermatid filaments. A layer of flattened, thin cells is found in the rete, which is changed to a columnar epithelium in the vasa efferentia and epididymis, to become again flat at the lower part of the epididymis and throughout the vas deferens.

The connective tissue of the testicle is delicate, but not abundant. In addition it is found that here and there are small aggregations of nucleated cells, limited by the spermatid tubules or by connective tissue.

The Hydatids of the Testicles are two small appendages of the organ, sometimes found in the neighborhood of the globus major of the epididymis. The

first of these is called the *hydatid of Morgagni*, a small pear-shaped mass, which contains fluid at its large extremity, but is solid at its junction with the testicle. The second is smaller, and appended to the under surface of the epididymis. It has a more distinct peduncle than the structure first named.

Organ of Giraldés.—The Organ of Giraldés (paradidymis) is in reality composed of two small bodies, the remains of a portion of the Wolffian body, which are lodged in front of the cord above the epididymis. They contain rudiments of tubular structures, ending in blind swollen extremities.

Bloodvessels.—The *arteries* of the testicle are derived from the spermatic artery. The artery of the vas deferens is derived from the inferior vesical.

The *veins* are numerous, and follow the direction of the spermatic cord, and are received in the single spermatic vein, which, on the right side, empties into the vena cava, but on the left is commonly received in the corresponding renal vein.

The lower part of the epididymis and the vas deferens return their blood through a small vein which finally empties into one of the tributaries to the epigastric veins.

Nerves.—The nerves are derived from the internal spermatic plexus and branches of the lumbar plexus.

Lymphatics.—The lymphatics join the lumbar glands.

The descent of the testicle.—A columnar mass pushes inward and upward from the bottom of the scrotal sac, ascending along the vaginal process, which it in part embraces. Cleland has traced within this mass fibres of the External and Internal Oblique muscles, as well as slips of superficial fascia; proof is lacking that these fibres exert traction upon the testicle in the manner taught by Hunter. As the testicle descends within the vaginal process, the fibres of the gubernacular cord (as the columnar mass has been called) appear to be pushed aside while the cord itself is shortened; and by the time the testicle is received within the scrotum, the vaginal process is constricted at the neck from the abdominal portion, and is subsequently separated from the abdominal peritoneum to form the serous sac of the testicle. The pedicle of the gubernacular cord now disappears, and the descent is complete.

THE VAS DEFERENS.

The Vas Deferens is the name given to the canal which unites the epididymis with the ejaculatory duct. It is a cord-like canal, and is remarkable for possessing very thick walls. The vas deferens is

divided into three portions, the scrotal, the pelvic, and the terminal portions.

The *scrotal portion* ascends from the globus minor of the epididymis as a constituent part of the spermatic cord. This portion lies behind the spermatic vessels.

The *pelvic portion* includes the vas deferens as it lies in the abdomen and the pelvis. At the internal abdominal ring the tube is covered with peritoneum, and leaves the spermatic vessels to pass over the iliac vessels. It curves thence downward, crossing the remains of the hypogastric vessels to get to the median side of the ureter, where it lies between the bladder and the rectum, adjacent to the vesiculæ seminales.

The *terminal portion* (ampulla) is slightly expanded before ending in the urethra.

The vas deferens is about twenty-four inches in length, from one to one-and-a-half line in diameter. The walls are composed of three coats, a fibrous, a muscular, and a mucous coat. The inner coat is covered with cylindrical non-ciliated epithelium.

The vas deferens can be felt by rectal palpation.

Variations.—The testicle may be absent in one side, constituting the condition of Monorchia. W. Gruber, who has analyzed three hundred cases of this condition, has determined that the right testicle is more frequently absent than the left, and that the procreative power of the individual is not impaired.

When the testicle is misplaced, as, for example, when lodged in the perineum, it is important to remember that the tunica vaginalis is liable to be continuous with the peritoneum. This is especially apt to be the case in the child. Jas. E. Adams¹ asserts that the liability diminishes as the adult condition is attained. He records a fatal issue of an attempt to restore a misplaced testicle.

The testicle of the right and of the left side may be lodged each in a separate pouch, which represents the half of the scrotum. Various degrees of union of these separate sacs up to the stage of normal development of the scrotum have been recorded. They often coexist with malformation of the penis, especially with hypospadias.

Ludwick² describes ten instances in which the testicle was lodged in the perineum; and other cases are mentioned by Humphry.³

REMARKS.—The testicle may be drawn back into the abdomen. Such retrocession is not uncommon in infancy. In the subjects of congenital inguinal hernia, the testicle may recede at the time the hernial protrusion is restored. In a case reported by H. W. Brock,⁴

which terminated fatally by peritonitis, the vas deferens was found looped in the inguinal canal, and the testicle lying in the right iliac region. The vas deferens overlapped and bound down the ascending colon just above the cæcum.—Persistent pain in the testicles, according to Richet,¹ has been found associated with aneurism of the descending aorta and compression of the sympathetic nerve.

THE VESICULÆ SEMINALES.

The Vesiculæ Seminales constitute a pair of appendages to the vasa deferentia. Each mass is made up of a convoluted tube, and presents, when in position, an elliptical and somewhat flattened convex figure which is acutely narrowed toward the lower end to be received in the notch of the prostate gland. The mass measures from one-and-a-half to two-and-a-half inches in length, and from four to six lines in width.

The vesiculæ seminales can be felt by palpation through the walls of the rectum.

Variations.—The right and the left mass are often symmetrical. The proportions stated may be exceeded.—There appears to be no correlation between the testicle and the vas deferens. The vas deferens is in no way impaired in subjects in whom the testicle of the corresponding side is absent.

Structure.—The tube when stretched out presents numerous short cæcal branches of various lengths. Sometimes the entire organ is composed of two main diverticuli of about equal length. Each vesicula seminalis is composed of three layers: an outer (fibrous), a middle (muscular), and an inner (mucous) layer. The layer last mentioned is marked by reticulations resembling those seen in the gall-bladder. Some elastic fibres are also present.

Luschka describes a layer of muscular fibres passing across both vesiculæ seminales from side to side, which he denominates the Compressor.

Each vesicula seminalis lies to the outer side of the termination of the vas deferens, between the bladder and the rectum, and above the prostate gland of its own side. It may be intimately held to the upper border of the gland last mentioned in an oblique direction upward and outward. It is in direct contact posteriorly with the fascial covering from the latter organ upward to the *cul-de-sac* of peritoneum termed by Devovilliers the prostatic peritoneal aponeurosis.

The *ejaculatory duct* is usually described as the common duct resulting from the union of the vas deferens and the termination of the vesiculæ seminalis. It is, however, constructively the continuation

¹ Lancet, May 27, 1871, 710.

² Dub. Quart. Journ., xix. 76.

³ Holmes's Sys. of Surg., vol. iv.

⁴ New York Med. Journ., 1873, 70.

¹ Anat. Chirurgicale, 569.

of the vas deferens after it has received the vesicula seminalis. It is a short tube, measuring one-half to three-quarters of an inch in length, which lies near the base of the prostate gland, and, penetrating the gland, converges toward its fellow of the opposite side, at the same time curving forward and upward to a point near the floor of the prostatic portion of the urethra, when the two tubes abruptly assume a parallel position, having the utricle between them, and empty into the urethra at the side of the veru montanum.—The walls of the ejaculatory duct are thinner than those of the vas deferens which they resemble. The epithelium is of the flat variety, and the muscular coat, according to Henle, is cavernous.

Bloodvessels.—The *arteries* are derived from the inferior vesical and the middle hemorrhoidal.

The *veins* are tributary to the pudendal plexus.

Nerves.—The nerves are derived from the inferior vesical plexus.

Lymphatics.—The lymphatics join the hypogastric gland.

THE COVERINGS OF THE TESTICLE.

The Testicle and the terminal portion of the spermatic cord are lodged in the *scrotum*, a musculo-cutaneous pouch or bag situated at the lower portion of the trunk in front of the perineum. The left testicle being somewhat the larger, hangs a little lower down than the right, and the corresponding half of the scrotum is the more capacious. The median line is marked by a *raphe* which is extended upward upon the under surface of the penis, and is continuous with the perineal raphe. The skin of the scrotum is thin, of a darkish tint, and furnished with numbers of short flattened hairs whose follicles with their associated sebaceous glands are conspicuous through the skin. The scrotal septum (*septum scroti*) extends the entire length of the region, and separates it into halves.

The coverings of the testicle may be arranged for convenience in tabular form as follows:—

Coverings of the Testicle.

Skin.	}	Integumental (scrotal).
Dartos.		
Intercolumnar Fascia,	}	Coverings derived from the abdominal wall.
Cremasteric Fascia,		
and Cremaster Muscle.		
Infundibuliform Fascia, or Fascia Propria.	}	General connective tissue about the testicle, and derived from the transversalis fascia and the sub-peritoneal connective tissue.
Tunica Vaginalis.		Serous membrane derived from the peritoneum.

The Dartos is a layer of non-striated muscular fibres which belongs to the tegumental system. When it contracts, it causes the skin to crease. Under the influence of cold the dartos contracts, but relaxes under the influence of warmth.

The Intercolumnar Fascia (Cowper's fascia) extends from the pillars of the external abdominal ring, and passes down over the testicle beneath the dartos.

The Cremaster muscle is composed of a few sparsely distributed loops of muscle-fibres, which, it is believed, originate from the Internal Oblique muscle. Associated with them, and constituting part of the same covering, is a thin layer of connective tissue, the *cremasteric fascia*.

The Fascia Propria (fascia propria of Cooper), infundibuliform fascia, which lies beneath the Cremaster, is a layer of connective tissue which envelops the testicle. It is continuous with the *transversalis fascia* and sub-peritoneal connective tissue at the external abdominal ring.

The Tunica Vaginalis is a serous membrane covering the testicle. Like serous membranes elsewhere, it possesses two layers—a visceral and a parietal. The visceral layer covers the outer aspect of the testicle and epididymis; the parietal layer is in contact with the fascia propria.

In retraction of the testicle the organ loses first the intercolumnar, then the cremasteric coverings, and finally the fascia propria.—Rektorzik¹ has described little club-shaped masses upon the outer covering of the cord. These are suspected to be of the same nature as the Pacchionian bodies of the arachnoid membrane.—Travers has described a hernia lodged in the *processus vaginalis*.—A rudimentary form of dartos has been detected by Sappey in the *labia majora*.—The Cremaster muscle acts with the abdominal muscles, and is contracted in such acts as coughing, crying, etc. It draws the testicle upward and outward.—The dartos raises the testicle vertically.

THE FEMALE ORGANS OF GENERATION.

The account of the Female Organs of Generation will include—

The Ovary.
The Fallopian Tubes.
The Uterus.
The Vagina.
The Vulva.²

¹ Sitz. der Wien. Acad., 1857, 23, Bd. p. 134.

² The account of the Urethra of the Female is appended to this group for convenience.

THE OVARY.

The Ovary (fig. 1, Plate CIX.) is the egg-producing organ. It is of an almond shape, and is situated between the folds of the broad ligament, but projects upon the surface of the posterior layer. It measures one inch and a half to two inches in length, by three-quarters of an inch in width, and is about one-half to one inch in thickness. Its weight is eighty-seven grains. The ovary is slightly thicker at its outer than at its inner end. It is convex upon its posterior surface, but flat on the anterior, where a depression is seen called the *hilum*. In addition to the support which it receives from the broad ligament, the ovary is connected with the uterus by the ovarian ligament, and to the infundibulum of the Fallopian tube by a process of the fimbriated border.

Structure.—The posterior surface of the ovary is covered with a special epithelium which, instead of being tessellated like that of the adjacent peritoneum, is columnar or prismatic. The ovary is composed of connective tissue containing groups of cells from which are developed the *ova*. The connective tissue has received the name of the *stroma*, and the nests of cells the name of the *Graafian follicles*.

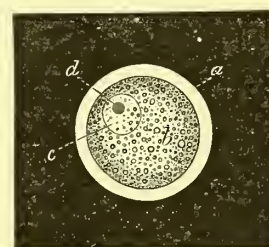
The *stroma* is condensed toward the periphery, where it assumes the appearance of the tunica albuginea of the testis. It is not sharply differentiated from the interior substance, though writers generally speak of the peripheral layer as the *cortex*, and the interior as the *medullary substance*. The medullary substance converges toward the hilum. Inter-mixed with the foregoing are bloodvessels and nerves, with some elastic tissue and muscular fibres. Those portions of the stroma towards the cortex, containing the ova, and sometimes called *parenchyma*, are largely composed of small spindle-cells disposed in variously interlacing bundles. The nature of these spindle-cells is still disputed; by some writers they are considered to be an imperfectly developed form of muscular tissue, by others but a modified connective tissue.

The primitive *Graafian follicles* are minute rounded masses of cells, from or among which the ova are proliferated or developed. The follicles are arranged in three sets. Those of the peripheral set are the most numerous, are smaller than the others, each follicle having a diameter of one one-hundredth of an inch, and are the most primitive and least developed. Great numbers exist in the ovary of the fœtus.

Those of the set below the foregoing are much fewer in number, but farther developed, and present a diameter ranging from one one-hundredth to one-twentieth of an inch.

The deepest set is composed of yet fewer and larger follicles. It is from these that the ova as a rule mature. They gradually come to the surface and discharge their ova, at the times when the ovary is clasped by the fimbriated extremity of the Fallopian tube. At the time of maturation of each ovum the follicle is limited by a distinct membrane, on the inner side of which are several layers of epithelial cells, the *membrana granulosa*; the mature follicle is usually distended with an albuminous fluid, the *liquor folliculi*; towards the centre of the sac is found the ovum, itself incased in several layers of cells—*discus proligerus*—which are connected by a stalk-like mass

Fig. 192.



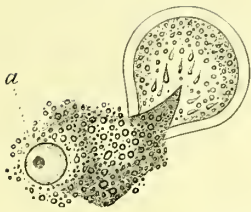
Human ovum magnified 75 diameters. a. Vitelline membrane. b. Vitellus. c. Germinative vesicle. d. Germinative spot.

with those lining the follicle. The entire cellular contents of the Graafian follicle—*membrana granulosa*, *discus proligerus*, and ovum—are descendants of the cells of the primary *germinal epithelium* of the fœtus.

After the escape of the egg, the cavity of the follicle becomes rapidly filled by a blood-clot, which, although primarily of a reddish-brown color, assumes in time a yellowish color, and has received from this circumstance the name of the *corpus luteum*. This coagulum disappears after the fourth month in the non-pregnant condition, but, should conception occur the *corpus luteum* develops and forms an oval figure, measuring three-fourths of an inch in length by one half of an inch in thickness, and persists during gestation. Between the sixth and the seventh months the corpus luteum contracts, and in the ninth month is greatly reduced in size. It does not entirely disappear, however, until the tenth month.

The *ovum* is a typical cell having a diameter one one-hundred-and-twentieth of an inch. It is inclosed by a distinct limiting membrane or cell-wall, the *zona pellucida*. The interior mass is called the *yolk*, and corresponds to the cell-contents. Floating within the yolk is a *nucleus*, measuring one seven-hundred-and-twentieth of an inch in diameter, which is called the *Graafian or germinal vesicle*, and within this a *nucleo-*

Fig. 193.



Human ovum, ruptured by pressure, showing the vitellus partially expelled, the germinal vesicle with its germinal spot, at *a*, and the smooth fracture of the vitelline membrane.

lus, measuring one three-thousandth of an inch in diameter, which is called the *macula germinativa*, or germinal spot.

Bloodvessels.—The ovary is supplied by the ovarian arteries, branches of the internal iliac. The veins form a bulb below the hilum which is analogous to the *corpus spongiosum*, and which is sometimes referred to under the name of pampiniform plexus. The ovarian vessels may become varicose, and under pressure may even rupture.

Lymphatics.—The lymphatics join the lumbar glands.

Relations.—The relations of the ovary are subject to great changes, which are more or less determined by the state of the uterus. In pregnancy the ovary is carried up to the side of the abdomen. After delivery it lies in the iliac fossa. In rare instances it has been found in the sac of a femoral or inguinal hernia. Barnes¹ gives the following as conclusions which may be drawn from a study of the *anomalies of relation of the ovaries*: “Such anomalies are frequently the result of inflammatory action. The most common is the adhesion with the Fallopian tube; next in frequency is the adhesion of the ovary, either with or without the tube, to the hinder wall of the uterus, and the neighboring parts of the broad ligament down to the bottom of the recto-vaginal pouch. These adhesions frequently result from puerperal peritonitis at a time when the uterus is above the usual size, filling the pelvic cavity, and when its appendages are thrown back to its posterior surface. Adhesions of the ovary also take place to the sides of the pelvis, to the rectum, to the sigmoid flexure, in consequence of pelvic peritonitis to which anomalous maturation and morbid processes in the ovaries or tubal catarrh has given rise.”

The Parovarium.—The parovarium is a group of small tubes varying from twelve to eighteen in number, which are lodged in the broad ligament between the Fallopian tube and the ovary. The tubules slightly converge from above downwards, and are united at their upper ends by a transverse tube, which is longer than the others. A small hydatiform enlargement is often seen in connection with the parovarium. The entire organ measures from two to three lines in width. The tubes are lined with ciliated epithe-

lium. The parovarium is a rudiment of a portion of the Wolffian body, and is homologous with the epididymis of the testis. It is not known to have any practical value. T. Grainger Stewart¹ described a cystic distension of the tubes of the right parovarium. In the same subject the Fallopian tubes terminated in *culs-de-sac*.

Variations.—Supernumerary ovaries are exceedingly rare. Puech² and Sinety³ have recorded examples.

REMARKS.—The ovary may be compressed by external palpation, as a result of which a peculiar pain is experienced. The organ is frequently the seat of neuralgia, which is remarkable for the varied reflexes excited. The ovary may be so far depressed from the position it normally occupies as to be felt by vaginal palpation, when it can be excised through the wall of the vagina. The organ has been repeatedly excised, either for removal of the large cysts or other outgrowths originating in it, or for the relief of obstinate hysterical conditions.

THE FALLOPIAN TUBE.

The Fallopian Tube (fig. 1, Plate CIX.) is the oviduct. It answers pretty accurately to the upper border of the broad ligament, which here holds to the tube a position analogous to that held by the mesentery to the ileum and jejunum. It measures about four inches in length, and is rarely symmetrical, the right being the larger. The Fallopian tube is conveniently divided into three portions:—

- (1) The infundibulum.
 - (2) The free tubal portion.
 - (3) The interstitial portion, included in the uterine wall.
- (1) The *infundibulum* (*morsus diaboli*, or pavilion) is a corolla-like expansion of the tube, designed to embrace the ovary at the time of the escape of the ovum. Its borders are furnished with numbers of rounded or pointed processes, which, from their resemblance to fringe, have been called *fimbriæ*. Some of these processes are arranged upon the sides of others, while the fimbriæ near the borders occasionally unite, causing a lattice-like appearance. One of the fringed processes extends from the ovary to this portion of the infundibulum. At the bottom of the infundibulum is the narrowed opening leading to the *ampulla* (q. v.)
- (2) The free tubal portion is widest at its outer end, but contracts toward the uterus. The outer half

¹ Journ. of Anat. and Phys., 1868, 243.

² Du Ovaries de leurs anomalies, Paris, 1873, 39.

³ Comptes Rendus de la Soc. de Biol., ii. 1875, 259.

¹ Loc. cit., p. 267.

or two-thirds differs in many particulars from the inner division. It is more movable, somewhat tortuous, and has been called by Henle, from its widened, flask-shape appearance, the *ampulla*.

The inner division, or *isthmus*, is usually about two inches in length and is straight and fixed. Its walls are of great thickness.

(3) The interstitial portion lies within the cornu of the uterus. It measures but 0.04 in. in length, and is straight or slightly concave from below.

The coverings of the Fallopian tubes are three in number, named from within outward as follows:—

The Mucous Membrane.

The Muscular Layer.

The Peritoneal or Serous Layer.

The mucous membrane is furnished with columnar epithelium bearing cilia. These extend upon the fimbriae, and may be detected even on their outer or peritoneal surface. Within the interstitial portion and isthmus the mucous membrane is smooth, and the diameter of the tube is exceedingly small, scarcely permitting the entrance of a bristle. The opening into the uterus is often found plugged with thick mucus. Within the ampulla the mucous membrane is arranged in longitudinal folds, which present a shaggy appearance, due to great numbers of irregular and often even dendritic villous appendages. In some respects they resemble the *fimbriae*, by forming lattice-work unions, thus converting portions of the mucous layer into a series of minute canals. When the walls of the ampulla are in apposition, it is probable that the folds are so applied one to another as practically to convert the grooves also into canals.

The muscular layer is composed, for the most part, of circular fibres; a few longitudinal fibres, however, are found lying to the outer side of the foregoing.

The peritoneal or serous membrane is loosely connected to the muscular layer. It does not surround the tube, the lower fourth being in contact with the connective tissue between the two layers of the broad ligament.

Relations.—The most important relation of the Fallopian tubes is the one entertained to the ovary. While the ovary and the Fallopian tube are practically disjunct, the slender attachment so frequently seen extending between the two, as well as the general inclination of the infundibulum, indicates that near approximation, if not direct contact of the two, is readily secured when the fimbriae are swollen. In most animals the oviduct is continuous with the ovary, but in man and the majority of vertebrates the two are thus structurally distinct.

The broad ligament, while associated in the main with the uterus, under which head it is described, retains the ovary within its folds, and presents a small free lateral border between the infundibulum and the pelvis, and from this fact is called by Henle the *infundibulo-pelvic ligament*. Alterations in the form and relations of this border must ensue upon displacement of the tube.

Variations.—The absence of the Fallopian tube is as a rule associated with absence of the ovary of the corresponding side. According to W. Krause, one or more associated initial openings may exist. The Fallopian tubes very rarely terminate in a cul-de-sac, one inch and a half from the body of the uterus; in which event a fibrous band of the same length as the tube continues thence to the anterior wall of the rectum.¹

REMARKS.—The Fallopian tube may become an ingredient of hernia. Both tubes may become very much enlarged under morbid influences, as for example the retention of the menstrual fluid. Barnes² states that blood, mucus, or pus formed in the uterus may thus be driven backward by the contraction of the uterus, distending the tubes, exciting inflammation in them, and perhaps leading to discharge into the peritoneal cavity. In a similar manner fluids injected into the uterus may excite contraction, and this contraction may thence drive the fluid along the tubes if its exit be impeded at the neck, either by flexion, or by the canal being filled too closely by the injecting tube. At the outer end of the tube, catarrhal inflammation often leads to adhesions of

¹ T. Grainger Stewart, Journ. of Anat. and Phys., May, 1866, 243.

² Loc. cit., p. 403.

EXPLANATION OF PLATE CIX.

Fig. 1. The ovaries, Fallopian tubes, uterus, and in part the vagina, from in front. The anterior wall of the vagina is removed.

Fig. 2. The external organs of generation in the female.

Fig. 3. The pelvic organs and external organs of generation

in the female displayed in an antero-posterior (sagittal) section. The vagina distended in a conventional position.

Fig. 4. The mammary gland—one portion of the gland is represented as dissected to display the lobules and connective-tissue loculi.

Fig 1

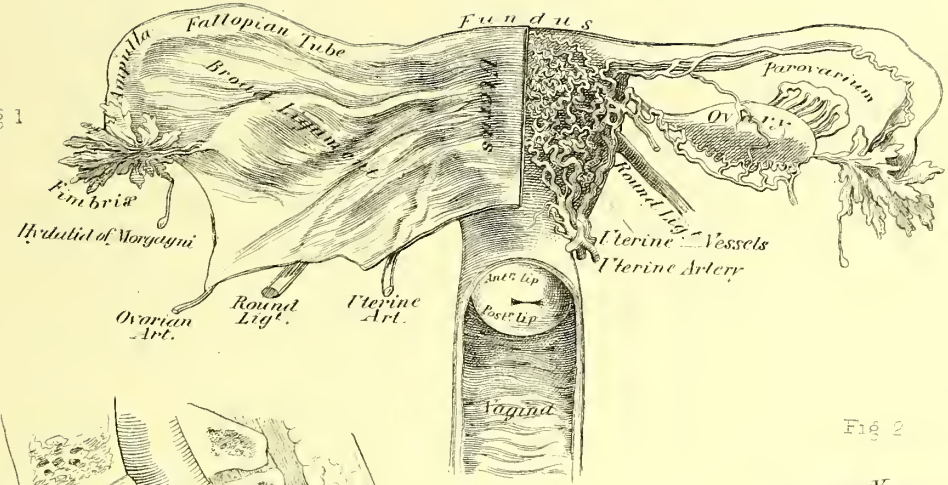


Fig 2

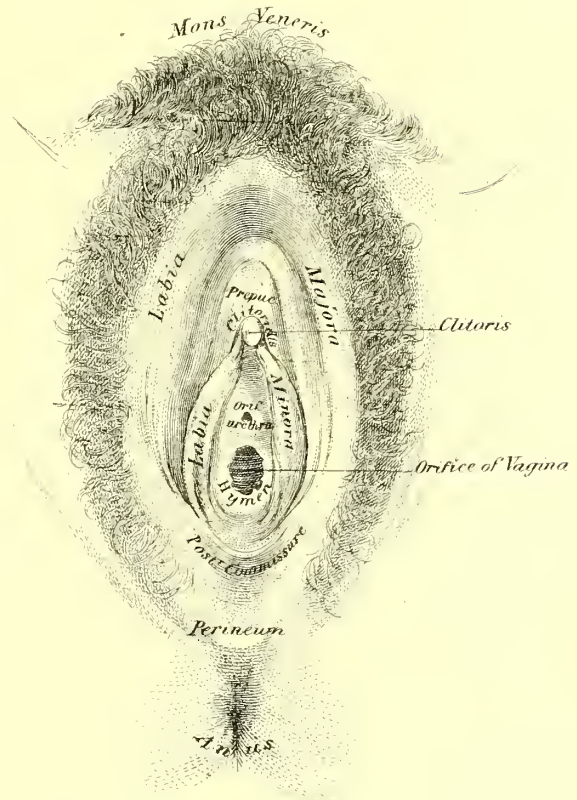


Fig. 3

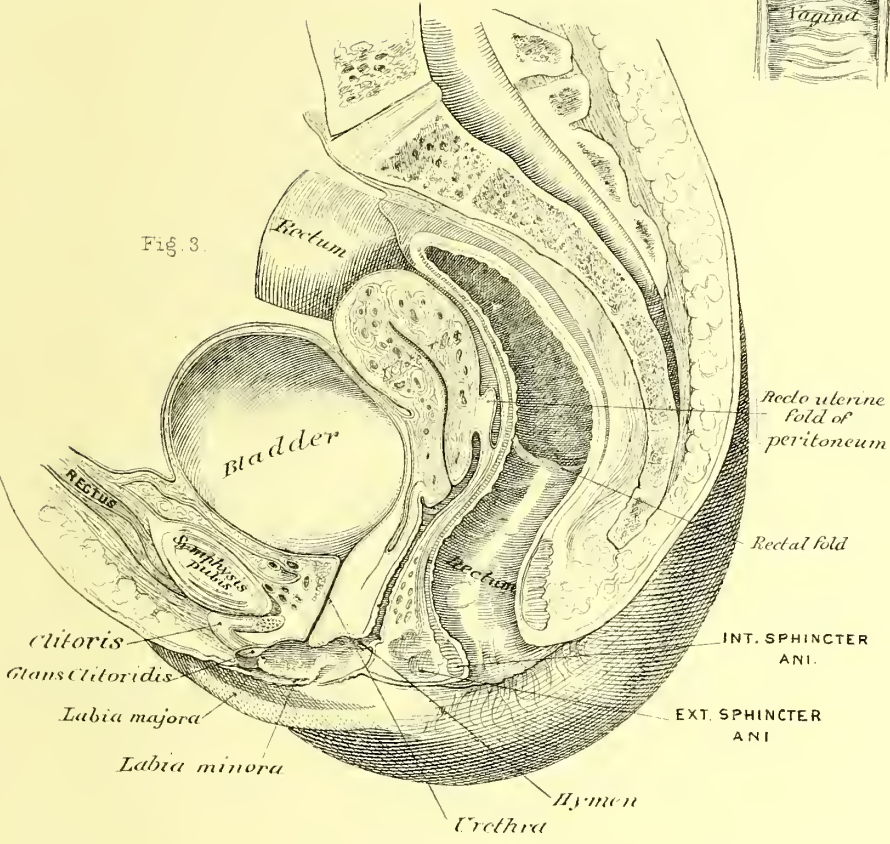
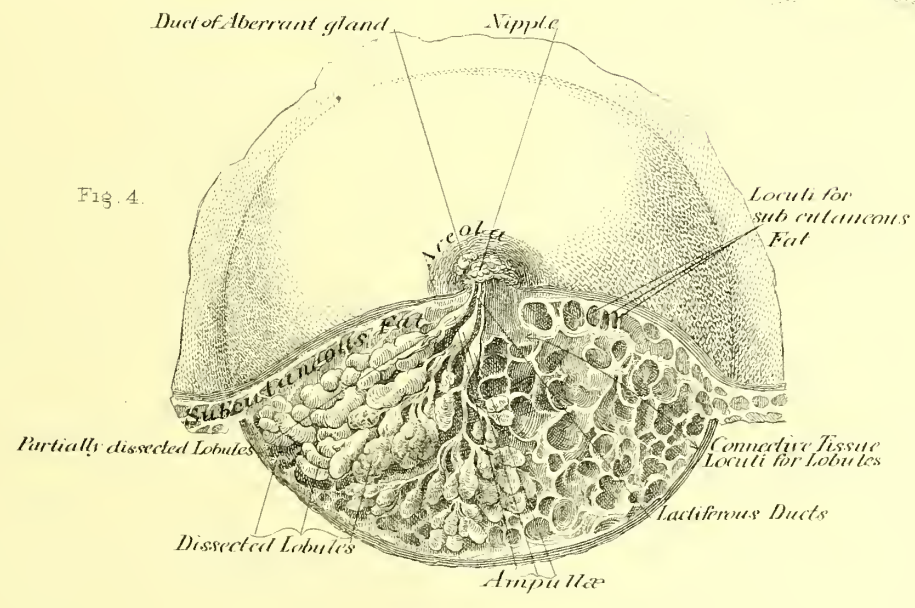


Fig. 4.



the fimbriæ, and, at the inner end, the swelling of the tube, owing to angular spurs, forms valve-like bendings, which shut off communication with the uterus.

THE UTERUS.

The Uterus (figs. 1 and 2, Plate CIX.) is a hollow muscular sac developed upon the female genital tract between the Fallopian tubes and the vagina. It is the organ of gestation and parturition. Its description will be based upon the organ as seen in the virgin and young adult.

It is situated in the cavity of the true pelvis, behind and above the bladder, in front of the rectum, and above the vagina. It lies in the median line, with a slight inclination from right to left. The uterus is so situated that a line drawn from the upper margin of the symphysis pubis to the lumbo-sacral articulation will intersect the upper margin of the fundus of the uterus. Another line drawn from the lower border of the symphysis pubis to the fourth sacral articulation will intersect the uterus on the lines of the upper limits of the vagina.

The uterus, when studied apart from its attachments, is seen to be of a pyriform figure, which is compressed from before backward. It is slightly concave at the sides, but convex upon its anterior and posterior surfaces, the latter being the more convex of the two. The organ weighs from seven to twelve drachms, and measures, according to Quain, three inches in length, two in breadth at its upper and wider parts, and nearly an inch in thickness.

The uterus is divided into the *fundus*, the *body*, and the *cervix*.

The *fundus* (base) is represented in that part above a line placed below the orifices of the Fallopian tubes. In the virgin the fundus is nearly straight, but in the adult who has borne children it is convex upward.

The body extends from the fundus to the beginning of the neck. It is usually represented as one-half the length of the uterus. Its outer surface is continuous with the neck, but within the interior the two are separated by a constriction called the *isthmus* or *internal os*. Both the fundus and neck are in direct relation with the peritoneum, which embraces them on all sides. Although it is exact to describe the body and fundus separately, the latter term will be selected in describing these portions of the organ as contrasted with the cervix.

The *cervix* (neck) is the remaining portion. It measures from six to eight lines in length, and is

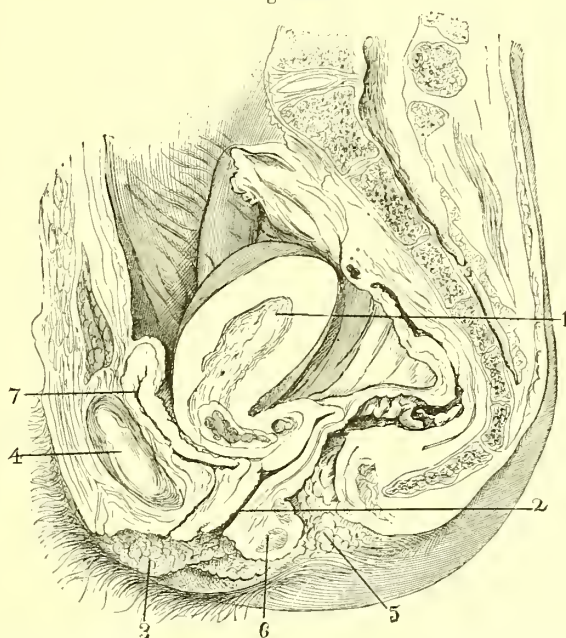
nearly cylindrical in form. Its lower fourth or fifth lies free within the vagina.

"The degree of this projection varies greatly. Thus in some specimens the vaginal portion forms a conical mass projecting an inch and a half into the vagina, while in others there is hardly any variation, the os uteri being almost flush with the vaginal roof."¹ It here forms two lips, an anterior and posterior, about a transverse slit, called the *external os* or *ostium*. The anterior lip is the thicker and shorter of the two, but, in consequence of the inclined position of the uterus, lies lower in the vagina.

The upper two-thirds of the neck on its anterior surface are united to the bladder by a thin layer of connective tissue. This relation, since it determines the general position of the uterus, explains many of its deviations in form.

Upon its posterior surface the neck above the vaginal portion is covered with peritoneum. This is less intimately adherent than to the body, and permits a quantity of fatty connective tissue to intervene. At the point immediately above the vaginal embrace, this tissue is pronounced, contains a few veins, and makes a fold in the peritoneum.

Fig. 194.



Antero-posterior (sagittal) section of the pelvic organs of the adult female. The uterus is gravid two months. 1, Uterus; 2, vagina; 3, vulva; 4, symphysis pubis; 5, anus; 6, perineum; 7, bladder.

The sides of the neck and body seen from in front present a concave surface, which accommodates the bloodvessels as they enter and escape from the uterus.

¹ Barnes, loc. cit., p. 233.

The *interior* is smooth, and presents in the body and fundus a triangular appearance, the orifices of the Fallopian tubes and the internal os yielding the angles. In the child-bearing woman the sides of the triangle are more regular than in the virgin, and are less convex.

The cavity of the neck is elliptical, being slightly narrowed at either end. It is circular at the internal os, but somewhat flattened elsewhere. It is marked by the two longitudinal ridges of muscular tissue, one on the front, the other on the hinder surface. Diverging obliquely from these are numbers of lines which cause the entire arrangement to be compared to a fern leaf, and has received from its general plant-like appearance the name of *arbor vitæ*. Henle describes the majority of the lateral rugæ as finally running parallel to the main longitudinal ridge. The two ridges are not exactly apposed according to Barnes, but are adapted side by side. According to Avelin, the thickness of the two sides of the cervix often varies considerably.

The substance of the uterus is of a uniform dark-grayish color, which is best seen in the fundus or body. It is of a spongy character. According to Duncan, under a certain degree of hydraulic pressure, air or liquid may be made to penetrate the entire thickness of the uterine wall. It resolves itself upon careful examination into an intricate association of unstriated muscular fibres. These are arranged from within outward as follows:—

1st. A circular layer continuous with that of the Fallopian tubes. It consists at the fundus of sphincter-like groups about the orifices of the tubes, and, lower down, of bands embracing the cavity of the uterus at low angles of intersection, but becomes circular at the lower end of the body to form the *internal os* or *isthmus*.

2d. Various placed oblique bands, which tend to surround the uterine vessels.

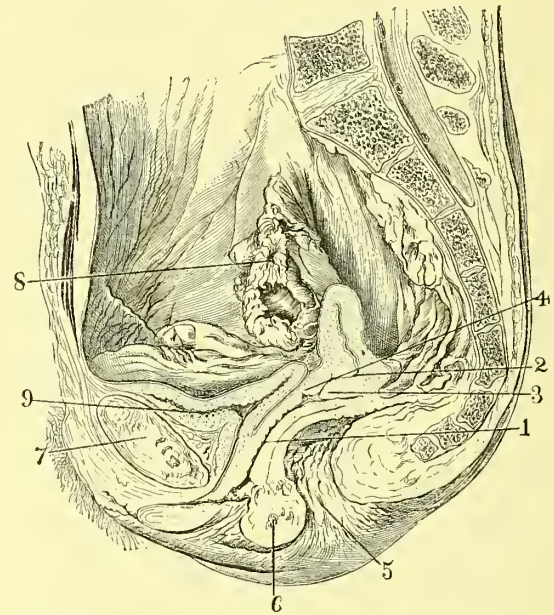
3d. Longitudinal bands, which are for the most part situated upon the posterior surface.

The ligaments of the uterus contain muscular fibre, which is continuous with that of the body of the uterus.

The *mucous membrane* in the body is thin and inconspicuous, but when carefully examined it is seen to be composed of a delicate basement membrane and columnar epithelial cells, which are furnished with cilia. Numerous minute glandular follicles beset the general internal surface of the uterine body and fundus, the orifices of which cause the mucous membrane to appear minutely punctate. These follicles are lined with a cubical, non-ciliated epithelium.

The mucous membrane of the neck differs markedly from that of the body in being of a grayish or rosy-white color, and in being much thicker. The entire surface is covered with squamous epithelium, and the lower third is furnished with villi. The glands of

Fig. 195.



Antero-posterior (sagittal) section of the pelvic organs of a virgin. 1, Vagina; 2, uterus; 3, posterior lip; 4, anterior lip; 5, anus; 6, perineum; 7, symphysis pubis; 8, fimbriated extremity of the Fallopian tube.

the cervix resemble those of the body, but yield a clear tenacious secretion which occupies the os. The *ovula Nobothi* are pellucid cyst-like bodies within the mucous membrane. They are held to be the result of distension of certain of the follicles.

The peritoneal investment of the fundus and body is complete, while that of the neck is restricted to the upper portion only. Not only is this the case, but the character of the investment differs, since in the former the membrane is directly united with the uterus, while in the latter some connective tissue intervenes. Hence while rupture of the body of the uterus induces hemorrhage in the abdominal cavity, a similar lesion of the cervix rarely does so. Indeed, the neck may be said to be surrounded by connective tissue, which is continuous with the connective tissue of the pelvis. It is distinctly traceable, according to Pansch, in the vesico-vaginal and recto-vaginal septa to a greater distance than has hitherto been supposed.

The peritoneum is more firmly united around the body on the posterior than on the anterior surface, while at the lower part, where it passes to form the broad ligament, it is looser.

At the point where the peritoneum is reflected from the neck of the uterus to the rectum and iliac fossa, a decided fold is seen containing connective tissue, fat, and bloodvessels. The contents of the fold communicates inferiorly with the pelvic connective tissue. The same connection is true of the anterior surface of the neck, which permits the creasing of its peritoneum in the anterior inclination of the body. Hence is explained the pronounced rim of indurated tissue which lies round the os uteri in some forms of pelvic cellulitis.¹

The Ligaments of the Uterus. The ligaments of the uterus include all those symmetrical folds of peritoneum and of fibrous tissue which extend from the uterus to adjacent structures. They are five in number, as follows:—

The Broad Ligament.

The Round Ligament.

The Ovarian Ligament.

The Utero-Sacral Ligament.

The Utero Vesical Ligament.

The *Broad Ligament* extends from the sides of the uterus to the sides of the pelvis. It is composed of two folds of peritoneum continuous with those inclosing the uterus. It obscures the lateral margins, and is nearly on the same plane with the anterior surface of the body of the uterus, thus permitting the posterior surface to project backward.

The upper border of the broad ligament receives the Fallopian tubes within, while below, it is reflected to enter into the floor of the pelvic cavity.

The *Round Ligaments* arise from the fundus of the uterus, a little in front of and below the Fallopian tubes. Each ligament passes forward as a rounded cord to enter the internal abdominal ring through which it passes to be lost upon the structure of the abdominal wall near the symphysis pubis. This extraordinary relation of a viscus thus holding structural relations to the superficies of the trunk is explained by Rainey,² who traces within the round ligament fasciculi of striped muscular fibre which are derived from the abdominal muscles.

The canal conducting the round ligament through the external abdominal ring is called the *canal of Nuck*. It is pervious, as a rule, only in the young.

The *Ovarian Ligaments* are two rounded fibrous cords containing muscle, which extend from the uterus to the ovary.

The *Utero-Sacral Ligaments* are two folds of peri-

toneum extending from the postero-lateral border of the uterus at the beginning of the neck to the sacrum. They define the pouch of Douglas. In a normal condition, the walls of this sac are in apposition. Great importance is assigned by Pansch to these ligaments. He asserts that their traction is nearly vertically upward, and that they not only tend to tilt the uterus forward, but that they pull the posterior wall of the vagina upward, thus accounting for the post-cervical vaginal pouch.

The *Utero-Vesical Ligaments* pass from the upper portion of the cervix of the uterus to the symphysis pubis. They define laterally the utero-vesical pouch, a shallow receptacle relatively of slight importance.

The last two ligaments, by reason of the muscular tissue they contain, exercise more than a passive function in sustaining the uterus in position. Malgaigne assigns special importance to the utero-sacral ligaments. According to this writer, decided falling of the uterus follows upon their division.

The pouch of Douglas is the most dependent of the pouches formed by the ligaments. Hence collections of fluid in the abdominal cavity will gravitate to this pocket. Marion Sims has suggested puncture of this cul-de-sac from the vagina, in order to secure an efficient outlet for such fluids as accrue after operations upon the peritoneal cavity, and more especially after ovariectomy.

When the relations of the uterus and ovaries and Fallopian tubes to the sac are remembered, it will be readily seen that blood escaping from these organs will collect in the pouch. Barnes thus assigns pelvic hæmatocele to it, and believes that blood appearing within the utero-vesical pouch would soon pass thence to the larger posterior pouch of Douglas.

Relations.—The relations of the uterus are complex by reason of the extreme mobility of the organ, and its changes in size and form in gestation. The following present the leading features of these relations:—

(1) As a primary fact, it may be stated that the uterus is composed of two portions—the body and the neck, which are in some degree physiologically distinct and have separate relations. The body is held in position by the broad ligaments (associated with a few muscular fasciculi distributed therein) and the uterine bloodvessels. The cervix is held in position by the posterior wall of the bladder and the utero-sacral and utero-vesical ligaments.—The body of the uterus is *suspended*; the cervix is in part only suspended (namely, at the point of vesical contact and by the antero-posterior ligaments), and is in great part *supported* by the vagina.—The entire uterus, according to D. Berry Hart,¹ is supported by the structures of the pelvic floor rather than by the so-

¹ Barnes, p. 574, fig. 99.

² Trans. Phil. Soc., 1850.

¹ The Surgical Anatomy of the Female Pelvic Floor, 24.

called ligaments.—The body and cervix also differ with respect to the peritoneum. The necessities of the growth of the pregnant uterus require *loose* but direct attachments laterally with the broad ligament, while the peritoneum is only indirectly related to the cervix uteri.

(2) In pregnancy the longitudinal axis of the body of the uterus inclines slightly to the left (a tendency seen even in the virgin state), at the same time that it is inclined upward and forward, perpendicularly to the plane of the superior pelvic strait. Thus it will be seen that the longitudinal axis is not a straight, but a curved line, having its concavity directed forward. According to Kohlrausch, the axis of the vaginal portion of the uterus at the time of menstruation is concave backward, thus making the line sigmoid.—The junction of the body with the cervix, it will be recalled, is marked by the isthmus in the interior, and by a creasing of the peritoneum on the anterior portion of the periphery.—A moderate degree of antelexion is normal.—The position of the uterus forms an obtuse angle with that of the vagina. Hence the lower end of the uterus is tilted against the posterior wall of the passage last named.

Bloodvessels.—The *arteries* are supplied by the uterine artery, the ovarian artery, and a small branch of the epigastric artery. The *veins* are tributary to the uterine plexus of veins (utero-vaginal plexus). A portion of the blood is returned by the ovarian veins.

Nerves.—The nerves are derived from the uterine plexus of nerves.

Lymphatics.—The lymphatics join the glands (hypogastric glands) situated about the branches of the internal iliac artery.¹

Variations.—The uterus may be absent, the Fallopian tubes uniting in a transverse band of muscle tissue, in the position of the normal uterus. The organ may be directly continuous with the vagina without the intervention of the os.—The organ may be composed of two long fusiform chambers, uniting in a short and imperfect body (*uterus bipartitis*), as in the mammals generally; when this disposition is but faintly expressed, the uterus is said to be *arcuated*; when pronounced, yet the two horns united by the matrix, the uterus is said to be *anvil-shaped* or *incudiform*; when one horn is alone developed, it is said to possess a *single horn*, and to constitute the variety of *uterus unicornis*.

When the uterus is of normal shape, but the cavity divided in part by a septum extending from the fundus, the organ is said to be *subseptate*, and to constitute the variety of *uterus subseptus*; when the septum above mentioned is complete, the organ is said to be *septate*, and to form the variety *uterus septus* or *uterus bi-ocularis*.—The uterus and vagina may be rarely duplicate throughout, while two

ovaries, two Fallopian tubes, and two round ligaments exist as in the normal state.

The malformation known as the two-horned or bifid uterus consists of the angles of conjunction of the fundus with the body being greatly exaggerated. This occurs at the expense of the fundus, which, under such conditions, never develops. The circular muscular fibres surrounding the orifices of the Fallopian tube are thus separated by an open space. The condition is normal in mammalia below the man-like apes.

Commonly limited to the body, the condition may extend to the cervix, but rarely reaches the vagina. Decès describes and figures a bifid uterus, one horn of which rupturing, from retained menstrual fluid, induced fatal peritonitis. Should pregnancy occur in one of two horns of a uterus whose general development is imperfect, a class of symptoms may arise closely resembling those of tubal pregnancy. The bicornuate uterus retains the embryo in one of its cavities, the pregnancy usually advancing normally to term. In studying specimens of the kind the observer is enabled to discriminate between it and a tubal gestation by the position of the round ligament. If it lies to the *lateral* side of the sac the fœtus has been retained in the horn of the uterus; if, on the other hand, the ligaments lie to the *median* side, the fœtus has been retained in the Fallopian tube.

REMARKS.—The uterus is so mobile that it can be thrown forward by a distended rectum, backward by a distended bladder, or it can be brought down to the plane of the vulvar outlet by gentle traction, a position favorable for some practical purposes, such as operations upon the cervix uteri.—The organ may be forced down by its own weight, constituting *prolapsus uteri*, as is commonly the case, or it may actually form a hernial projection, forming the so-called hysterocele. It has been found as one of the contents of a femoral or inguinal hernial sac, and may be forced up by pressure from below, or deflected from side to side, or from before backward. In marked retroversion the os may actually compress the urethra, as in anteversion, or it may lie toward the sacrum.—The separate physiological and mechanical value of the body and cervix will often express itself in morbid conditions. Thus the body, being, it may be, imperfectly involuted from the proportions of gestation, may sag forward or backward. Tumors may so press upon the organ as to attenuate the union between the body and the cervix. It may be squeezed between an hæmatocele in Douglas's pouch and the bladder. Or a distended bladder may throw it toward the sacrum. The last-mentioned fact is one of great practical importance when it is desired to examine the position of the body of the uterus through the abdominal wall. The previous complete removal of the contents of the bladder facilitates the examination.

¹ See J. Hoggan and F. E. Hoggan, Journ. of Anat. and Physiol., 1882, xvi. 51.

Among other patho-anatomical relations may be mentioned the possibility of the occurrence of abscess in the connective tissue between the bladder and the uterus, a fact well authenticated by Barnes, and for which we may be prepared when, as Kohlrusch informs us, the union between the two organs is such that it is difficult to identify the tissue as distinct from the muscular fibre of the two organs.—The round ligament is vascular, and is especially rich in veins. These may become varicose, and according to Cruveilhier may simulate hernia. The canal of Nuck is rarely persistent, when it may serve for the easy descent of a hernial protrusion.—W. L. Atlee¹ narrates an instance of an enormous collection of retained menstrual fluid in the posterior division of a bicornuate uterus.

THE VAGINA.

The Vagina² (figs. 1 and 3, Plate CIX.; figs. 193, 194) is a musculo-membranous canal extending from the uterus to the vulva. It is narrowed below, and joins the vulva by a vertical slit-like orifice. It receives above the lower third of the neck of the uterus. It is slightly curved from before backward, but preserves in the main the axis of the true pelvis. When its relations are undisturbed the length of the vagina is not greater than two-and-a-half inches. It can, however, easily be extended to four inches, which is usually given as the normal length. The posterior wall is found to be five lines longer than the anterior. The walls of the vagina are for the most part in apposition, but can without undue violence be separated one inch, which may be said to be the diameter of the parts in the virgin.

At the level of the hymen and under the influence of the Sphincter Vaginæ the lower portion of the vagina is the narrowest; the upper part (fornix vaginæ) is maintained in a nearly cylindrical form by the neck of the uterus; the form of the intermediate portion is dependent upon the condition of the bladder and of the rectum, but may be said to be flattened from before backward.

The inner surface of the vagina presents two longitudinal elevations—one on the anterior, the other on the posterior surface—termed the *columns*. Associated with each column are a number of *rugæ*, arranged

transversely to a median longitudinal ridge; they recall the roughened elevations on the hard palate. When a transverse section of the vagina is made the two columns are seen touching. This appearance is much modified by child-birth. The columns and rugæ become faint above, and may entirely disappear. The rugæ are more persistent on the anterior than on the posterior wall, and are always constant toward the lower part of the anterior column. The fact last mentioned is of practical importance, since the column forms a prominent swelling which, by its relation to the posterior wall of the vagina, closes the vestibule posteriorly. The constancy of the position of the anterior column is of great value in introducing the catheter by serving as a guide to the position of the urethral orifice.

Directly in front of the rugous swelling just described is the *hymen*. This is a crescentic fold of mucous membrane jutting forward into the lumen of the vagina from the posterior and lateral walls. It is thicker at the attached than at the free border. The hymen, as a rule, indicates virginity. It appears early in the foetus and persists until coitus; after which act the remains of the hymen are seen as fimbriæ or scar-like nodules, termed the *caruncule myrtiliformes*.

The foregoing description answers to the average condition of the parts. The hymen, it is necessary to state, is subject to great variation. The importance of variation both in practical medicine and in medico-legal studies has led to their careful consideration. The existing state of knowledge on the subject may be epitomized as follows:—

(1) The hymen may not be ruptured in coitus, and after the act may recover its virgin appearance. (2) The opening may be torn or dilated by the finger or instruments. (3) It may be imperforate, causing retention of the menstrual fluid.

Luschka has described as among the unusual variations of the hymen a fimbriated form; and Hyrtl mentions the rare occurrence of a hymen furnished with more than one opening.

The bulb of the vagina.—Under this name are included two erectile organs which are situated upon the lateral walls near the inferior orifice of the vagina, and which are believed to be homologous with the spongy body of the male. Each portion is elongated and leech-like in form, the inner surface concave, the outer surface convex, and the whole embraced by the Sphincter Vaginæ muscle.

Relations.—The vagina is placed between the bladder and the rectum. The anterior wall is thus described as entering into the *vesico-vaginal septum*, and the posterior entering into the *recto-vaginal septum*. The pelvic connective

¹ Ovarian Tumors, 301.

² The figures on Plate CIX. represent the vagina distended, and may be said to represent the conventional view. The actual disposition of parts, as seen in carefully made sections, varies greatly in different subjects; two views are given in figs. 193 and 194, from D. B. Hart.

tissue is continuous with that round the neck of the uterus, and thence can be traced down a short distance about the vaginal wall. In consequence of this arrangement the bladder and rectum are less intimately associated with each other than with the lower part of the vagina.

The anterior wall of the vagina is continuous below with that of the urethra, hence the name *urethro-vaginal septum* given to this region. This septum is thickest at its lowest part, where it measures five-and-a-half lines.

The posterior wall of the vagina enters for the most part into the recto-vaginal septum. As is the case with the vesico-vaginal, the lower part of this septum is the thicker. The upper fifth of the posterior wall is in contact with the peritoneum at the bottom of Douglas's pouch. This is a most important relation, and should also be remembered in connection with the course of the ureters. The ureters lie about four lines from the vagina, and between it and the Levator Ani muscles, at the upper portion of the canal, to which they are joined by connective tissue. Communication of the ureter with the vagina is possible, as shown by W. A. Freund.¹

Structure.—The vagina is composed of three coverings, the mucous membrane, muscular tissue, and dense connective tissue. These are not arranged in well-defined layers, but are placed in the order named from within outward.

The mucous membrane is covered by a thick squamous epithelium. The papillæ are large, but concealed by the epithelium. The glands of the vagina are indifferently developed. A few sparse racemose glands are named by Luschka as occurring at the orifice and at the upper portion of the vagina. The remaining glands are of the closed variety, and are insignificant. Some writers describe mucous follicles in the vaginal vault.

The muscular fibres of the vagina are of two kinds, longitudinal and circular. The latter are the more external. Interspersed among the fibres is a quantity of connective tissue (rich in elastic fibres), which extends beyond the muscular fibres, and serves to separate the vagina from the bladder and rectum respectively.

As already mentioned, the orifice of the vagina is surrounded by the Sphincter Vaginæ, a thin bundle of striped muscular fibres derived from the tegumental layer of the perineum.

Variations.—The vagina may be absent, narrowed, or may exist as a *cul-de-sac* opening on the perineum in the normal manner. The hymen may be imperforate and of great thickness. A septum may extend either wholly or in part along the vagina, thus converting the single passage into two. The hymen may be present in both passages. Very infrequently

two uteri may be found in conjunction with the vaginæ, but commonly the septum ends at a point below the os.

The vagina, together with the bladder, may form a uro-genital sinus, into which the rectum opens, and thus form a chamber which, in the new-born subject, will be found filled with meconium. Atresia of the rectum, the vagina, and the bladder may coexist with Sympodius (*q. v.*).

REMARKS.—In women who have borne children the vagina is bag-like, and wider than in the virgin. The contracted orifice maintains a condition favorable to the retention of clots in uterine hemorrhage, as well as of menstrual fluid.

The vagina is susceptible of inversion from the dragging downward of a displaced uterus, and of distension from the descent of the fœtus in child-birth.

Its walls may be involved in penetrating wounds of the vulva and the perineum. Such wounds, if extensive, may perforate both walls and involve the bladder or the rectum, and possibly the peritoneum (see Fig. 194).

In the genu-pectoral position, the vagina becomes distended with air, and the examination of its walls is greatly facilitated.

The posterior wall of the vagina is tense in parturition, when it may be ruptured by injudicious pressure from instruments. Instances have been recorded of extensive lesion of the vagina under the conditions named with protrusion of loops of the sigmoid flexure.

For clinical purposes the vagina may be divided by three planes which intersect the passage at right angles to the longitudinal axis: (1) The parts on and just above the level of the hymen include that portion of the vagina which answers to the urethra as it lies *below* the symphysis pubis. The clinical relations of this portion are with the vestibule and the so-called true perineum. (2) The parts answering to the portion of the urethra lying *behind* the symphysis pubis. Here the clinical relations are with the urethra in front and the rectum behind. (3) The parts answering to the vaginal vault; these relate to the peritoneum both front and back in contracted states of the bladder and the rectum, and with the bladder-wall chiefly in front in distended states of the bladder. It is in this section that peritoneal involvement from vaginal lesion can occur, and that the ovary can be excised.

THE VULVA.

The Vulva (fig. 3, Plate CIX.; figs. 194, 195) includes the external organs of generation.

¹ Klin. Beiträge zur Gynäkologie, Heft i. 1862, 59.

The parts so included are :—

The Mons Veneris.

The Labia Majora.

The Labia Minora.

The Clitoris.

The Glands of Bartholin.

The bulk of the Mons Veneris is due to a cushion of fat covering the pubis. It is continuous above with the skin of the abdomen, and below with the labia majora.

The Labia Majora is the name given to a pair of divergent folds of skin and inclosed fatty tissue forming the lateral boundary of the vulva. These folds are thicker above than below, and are commonly covered on the outer side for the most part with a sparse growth of hair. The lower ends terminate at about an inch in advance of the anus at a small transverse fold termed the *commissure*, which is at once the posterior boundary of the vulva and the anterior boundary of the female perineum.

Directly in front of the commissure lies a shallow depression, which has received the name of the *fossa navicularis*. In advance of this is a delicate transverse fold known as the *fourchette*.

The Labia Minora (nymphæ) are two thin mucodermic folds, lying directly within the labia majora. They arise from the sides of the prominence of the clitoris with the integument covering with which they are continuous. They terminate below at the sides of the orifice of the vagina.

Luschka describes the nymphæ as forming a small transverse fold posteriorly; this, in his opinion, is the *fourchette*, which would thus be removed from the labia majora. See, also, *infra*, in quotation from M. Duncan.

The *vestibule* is a term restricted to that portion of the vulva bounded laterally by the nymphæ, above by the clitoris, behind by the fourchette, and within and behind by the upper margin of the orifice of the vagina, by the hymen, or by its remains.

The Clitoris is a symmetrical organ representing a rudimentary penis. It is composed of a pair of cavernous bodies each of which arises from the descending rami of the pubis and the ascending ramus of the ischium. These bodies are held together anteriorly by a fibrous membrane, analogous to a rudimentary *septum pectiniforme*. The clitoris measures one-and-a-half inch in length, and can be felt beneath the skin covering. The free end of the organ lies in a cap-like fold of skin which has been compared to the prepuce, and the inclosed part to the glans penis. No such structure, however, as a glans exists in the clitoris. It consists only of the cavernous bodies.

The Glands of Bartholin (vulvo-vaginal glands, glands of Duverney), are two in number.

Each is a racemose gland about a third to half an inch in diameter, and of a rounded or reniform outline, and is yellowish-red in color. It is situated between the cellular tissue of the vaginal wall and the Constrictor muscle of the vagina, and behind the lower part of the spongy body. The duct, about half an inch in length, passes forward to open between the nymphæ and the hymen.

The glands secrete a mucoid fluid, and are most active during the child-bearing period.

The mucous membrane of the vulva is smooth, pink in color, and covered with squamous epithelium. It possesses numerous simple racemose gland follicles, on the inner side of the nymphæ and about the urethral orifice. Sebaceous glands are found beneath the fold of skin at the free end of the clitoris, on the outer side of the nymphæ, and upon the labia majora. The papillæ of the mucous surface are as a rule well developed, and are abundant upon the inner surfaces of the nymphæ, where they assist in the sexual impression.

Bloodvessels.—The *arteries* of the vulva are derived for the most part from branches of the internal pudic; a superficial branch is derived from the superficial external branch of the pudic for the outer parts. The *veins* communicate with the *bulb*, with the vaginal plexus, and thence for the most part with the obturator veins. Some of the superficial blood returns by the external pudic vein to the femoral vein.

Nerves.—The *nerves* are branches of the ilio-inguinal and genito-crural nerves of the lumbar plexus.

Lymphatics.—The lymphatics join the inguinal and the internal iliac glands.

REMARKS.—The labia majora, receiving as they do both bloodvessels and nerves from distinct sources, may be involved in common with the parts relating to the lower limbs or with the pelvic organs. The engorgement of the lymphatics of the lower extremity, as in "milk-leg," may involve the vulvar lymphatics, while epithelioma of the labia majora will involve by extension the lymphatics of the pelvis.—The clinical relations of the nymphæ and the clitoris are entirely with the pelvis.

The peculiarities of the vulvar and vaginal orifices before and after the birth of a child are well described by M. Duncan. Since these conditions have exact clinical values, the remarks of this writer are copied in full.

"In the primipara the outer or larger margin of

the hymen, or its margin of insertion, is the exact limit of the vagina at the margin of the vaginal orifice. Close to the anterior or upper margin of the orifice is the urethra. At the sides of the orifice are the lower ends of the nymphæ, but there is quite a considerable interval between them and the vaginal orifice. Remote from the nymphæ, and closely adjoining the posterior margin of the vaginal orifice, are the openings of the glands of Duverney (glands of Bartholin). These openings are in the fossa navicularis. The last-named fossa lies between the orifice of the vagina and the commissure or anterior marginal portion of the perineum. The labia majora are not united posteriorly, but form separate pieces parallel to and touching one another, at the same time they end somewhat abruptly."

The effect of the first birth upon the above arrangement is the following:—

"The hymen is partially or completely destroyed. If the orifices of the ducts of Duverney's glands are not discernible, it is impossible to say exactly where any part of the vaginal orifice is, except when distinct remains of the hymen are seen. The distinction of the fourchette or posterior margin of the vulvar outlet from the margin of the vaginal orifice cannot now be made with any exactness. The labia majora have shrivelled, and the position of their projecting posterior parts is ill defined. If in a multipara the head is obstructed by the undilatability of the orifice of exit from the woman's body, then it cannot be said that the vaginal orifice is rigid and obstructing, for that part is not recognizable. It is the vulvar outlet that by its undilatability impedes progress."

THE URETHRA IN THE FEMALE.

The Female Urethra¹ (figs. 2, 3, Plate CIX.; figs. 192, 193) opens within the vestibule about midway between the clitoris and the hymen. The urethra is a small slit-like passage about one-and-a-half inch long, and presents a diameter of three to four lines; it is somewhat wider toward the bladder. Its mucous membrane is of a whitish color, and is thrown into a number of longitudinal plications. The membrane receives the orifices of a number of muciparous follicles which lie for the most part in the sulci between the folds. The minute anatomy of the female urethra reveals a structure recalling that of the male urethra. Thus, it possesses a scaly epithelium becoming tessel-

lated toward the bladder. Beyond this is a layer rich in veins, and beyond this between the layers of the triangular ligament it is embraced by the Compressor Urethræ muscle. It differs from the male canal, however, by the increased quantity of elastic tissue.

M. Merle¹ states that, owing to the subjacent connective tissue being lax in the female, the urethra is prone to prolapsus in inflammatory engorgement such as is seen in gonorrhœa. Thus, this condition is based upon an anatomical relation distinguishing the female urethra.

According to J. Englisch,² the mucous membrane of the urethra exhibits larger glands upon the posterior and lateral walls than elsewhere. These glands are liable to cystic distension in the fœtus, leading at times to prenatal occlusion of the urethra, and retention of urine. The etiology of the cysts "lies in the peculiar disposition manifested in the last months of fœtal life to the adhesion of superficial layers, which in males shows itself in the closure of the sinus pocularis. The cyst may be often discovered projecting from the urethral orifice."

The short and simple tract of the female urethra, and the yielding character of the tissues surrounding it, enable the surgeon to examine the interior of the bladder through this passage more readily than is possible with the male. Foreign bodies and calculi are removed with relative ease. Stricture of the female urethra for evident reasons is an insignificant affection as compared with that of the male urethra, and is never induced by gonorrhœa, but invariably by the results of violence, more particularly following injuries of the parts in labor.³—The urethra is elongated during parturition to twice or three times its ordinary length. It is at such times necessary to use a long elastic catheter to reach the bladder.⁴

THE FEMALE PERINEUM.

The Female Perineum includes the structures occupying the inferior pelvic outlet. It constitutes the true pelvic floor, and is a thick fleshy diaphragm which presents inferiorly a convex, and superiorly a concave surface. The plane of the floor is interrupted by the vesical, vaginal, and rectal outlets, lines extending from which serve to limit the subdivisions of the perineum.

The female perineum is divided into a pubic and a sacral segment.

The *pubic segment* consists of that portion which extends from the symphysis pubis to the anterior

¹ The account of the urethra naturally follows that of the bladder. The description of the female urethra, since its relations are chiefly with the vulva, is here introduced under the general heading of the female organs of generation.

¹ Archiv. Gén. de Méd., Avril 28, 1867.

² Wien. Med. Jahrbuch., iii. 373; tr. in N. Y. Med. Journ., xx. 653.

³ T. B. Curling, Lancet, i. 634.

⁴ For an elaborate description of the urethra in the female with figures, see M. Schüller, Virchow's Archiv, 1883, cxiii. 405.

vaginal wall inclusive, and is for the most part composed of the bladder. It is loose in its attachments; is drawn up during labor; is driven down in prolapsus uteri, and falls forward in the genu-pectoral position.

The pubic segment, as seen on a median antero-posterior (sagittal) section, is triangular in shape, and exhibits a pubic, a vaginal, and a peritoneal aspect. The *pubic aspect* is nearly two inches and a half (six cm.) long, and is separated from the symphysis pubis by a pyramidal mass of fat. The *vaginal aspect* is three and a third inches (eight cm.) long, and is closely incorporated with the anterior vaginal wall. The *peritoneal aspect* is of the same length as the pubic.

The *sacral segment* extends from the posterior vaginal wall to the sacrum. It is somewhat quadrangular, and is composed of musculo-tendinous tissue. The lower end of the structures entering into the anterior wall constitutes the so-called "perineal body." The sacral segment is firm in its attachments; is drawn down in labor; always remains in position (posterior vaginal wall excepted) in prolapsus uteri, as well as in the genu-pectoral position.

The superficies of the parts entering into the female perineum embrace, (1) the space between the tip of the coccyx and the anus; (2) the anus itself; (3) the space between the anus and the commissure; (4) the vulva. In practice, however, it is customary to restrict the term perineum to the third of the above-named divisions.

The female perineum (perineal body), (Fig. 192, Fig. 193), when thus restricted, is the superficies of the anterior portion of the sacral segment of the pelvic floor. When seen as part of an antero-posterior (sagittal) section (Figs. 194 and 195), it is a broad musculo-tendinous surface, which forms a conspicuous feature in the dissection; it is covered with skin on its free and inferior aspect; but is continuous with the mucous surface of the vagina anteriorly, and the mucous surface of the rectum posteriorly. Its superior limit is not well defined in the dead subject, but in the living can be said to correspond to the plane of the upper limit of the Internal Sphincter Ani muscle.¹

According to Jas. St. Clair Gray,² there is great diversity in the position, length, and relation of the perineum to the pubis and the coccyx. When the perineum is long and its anterior margin is near the pubis, it may be termed *pubical*; when shorter

and equidistant from the pubis and coccyx, it may be termed *axial*; and when nearer the coccyx, *coccygeal*.

In connection with this subject, it may be here appended that the orifice of the vagina is not constant in its position relatively to the pubis and coccyx, nor is the direction of its cavity invariable. The sacrum is inconstant in form. It varies in the degree of curvature of its anterior surface, and when the curvature is slight the perineum has an axis which answers to the *coccygeal*; when moderate, the axis is central or *axial*; and when the curvature is exaggerated, the axis is *pubical*. Thus differences in the position of the perineum correspond with degrees of curvature of the sacrum.

THE MAMMÆ.

The Mammæ (mammary glands) (fig. 4, Plate CIX.) are the milk-producing organs. They are subcutaneous bodies, situated one on each side of the front of the thorax, over the Pectoralis Major muscle. They are characteristic of the highest group of the animal kingdom, the mammalia.

The mammæ are equally active in both sexes in utero; are equally inactive during infancy and adolescence; but differ remarkably during the years of fertility. The description, here adopted, relates, unless otherwise stated, to the glands in the child-bearing woman.

The mammmæ are generally described with the organs of reproduction, in consequence of their development proceeding coincidently with these organs. In the female before puberty, and in the male throughout life, the mammæ remain in a rudimentary condition.

Each mammary gland forms a hemispherical or sub-conical eminence—the breast—surmounted by the nipple, and diverges slightly from its fellow. It is somewhat flattened above, convex below, slopes gently toward the axilla, extends from the third to the seventh rib, and from the outer border of the sternum to the anterior border of the axilla.

The nipple is of a deep brown color in the brunette; the areola assumes a peculiar brownish hue in pregnancy. It lies as a rule opposite the fourth intercostal space. It is often over the fourth rib, less frequently on the fifth rib, and rarely upon the fifth intercostal space, and lies four and three-quarters of an inch (twelve cm.) from the median line of the sternum. According to Holden, a line

¹ The above account is based for the most part upon the researches of D. B. Hart, *The Structural Anatomy of the Female Pelvic Floor*, Edinburgh, 1880.—See also *Edinburgh Medical Journ.* xx.; also, B. E. Holden, *Am. Journ. Obst., etc.*, xvii. 1884, 365.

² *Glas. Med. Journ.*, 1874, 182.

drawn round the chest through the nipple crosses the sixth intercostal space midway between the sternum and the spine.

Scattered over the areola are from five to ten minute wart-like growths, the papillæ; these represent the terminal points of minute glands, which, from their resemblance to the mammæ, are called the *accessory lacteal glands*. They present an average diameter of one line. They are not to be confounded with the *sebaceous* glands which exist here as upon other portions of the general skin surface, and open *between* the papillæ; but they have especial significance here, since they lubricate the nipples during the act of sucking, and thus prevent excoriation of the delicate skin of the nipple which would in their absence occur.

Measurements.—The mammary gland measures from three-and-a-half to four-and-a-half inches in diameter, and from one-and-a-half to five inches in thickness.

Upon its removal the gland is observed to have a slightly concave base, which rests upon the Great Pectoral muscle, and in a well-developed condition even encroaches upon the Serratus Magnus muscle. It is surrounded by abundant connective tissue and fat. The former is of importance in retaining the gland in position, and is especially well developed at the upper portion, where it has received from A. Cooper the name of the *suspensory ligament* of the breast.

Beneath the mamma lies a bursa (sub-mammary bursa) which enables the gland to be freely moved upon the wall of the chest. To demonstrate the bursa an incision can be made which bisects the gland. The outer (lateral) half of the gland can then be turned outward toward the axilla, and the bursa is exposed.

The sub-mammary connective tissue following the strain of successive periods of lactation becomes relaxed, when the mammæ hang, udder-like, upon the thorax. This condition is especially well developed in women in savagery—the gland at no time receiving artificial support. In some African tribes it has been asserted that the breast may be slung over the shoulder in suckling the child, which is strapped to the back.

Structure.—A section of the mamma exhibits a whitish-yellow parenchyma, streaked here and there with a pinkish color. It is composed of from twelve to fifteen lobules which converge and terminate by as many orifices at the nipple.¹ The lobules widen toward the periphery, and are composed of vesicular terminations (*acini*), closely resembling the plan of structure of the racemose glands of the mucous membrane. These have received the name of the *lactiferous ducts* (*galactophorous ducts*). As they are

about to terminate in the nipple, each forms a fusiform expansion (ampulla), and within the nipple becomes much contracted. The diameter of a duct is one-twenty-fourth of a line, that of an ampulla from two to four-and-a-half lines, and that of the termination of a duct in the nipple one-twelfth of a line.

The ducts contain abundant elastic tissue in the walls, but no muscular fibre. The cells in the vesicles are rounded or sub-angulated; the epithelial cells of the ducts are short, and columnar.

The nipple contains unstriated muscular fibres, which are arranged in intersecting circular bundles. A few straight fasciculi pass from without inward.

Since in lactation the milk is being constantly secreted, it tends to flow forward from the vesicles. But, unlike the racemose glands elsewhere, the orifices of the ducts, in addition to being much narrowed, are actually closed by muscular contraction. The milk is thus retained in the ducts, more especially in the region of the ampullæ, until the infant, being placed at the breast, elongates and relaxes the constricting fibres (aided by the vacuum created by the act of sucking), and causes the milk to flow.

Bloodvessels.—The *arteries* supplying the gland are branches of the long thoracic, the acromial thoracic, the internal mammary, and the intercostal arteries. The *veins* belong to the superficial cutaneous veins.

Lymphatics.—The lymphatics are large and numerous. They terminate for the most part in the axilla, although some join the glands in the mediastinum.

Nerves.—The nerves for the skin are derived from the supra-clavicular, and the external branches of the intercostals from the second to the sixth, as well as branches derived from the brachial plexus. The parenchyma is supplied by the fourth to the sixth intercostal nerves. According to Luschka, Pacinian corpuscles are found upon the terminal twigs of the nerves about the nipple.

Variation.—The mammæ are subject to variation in numbers and position. Examples of such are, however, rare. Three supernumerary glands have been found associated with the normally situated mammæ. Instances of single supernumerary glands have been recorded, situated in the regions of the back, of the axilla, and of the thigh. In the latter instance the gland afforded an abundant secretion.¹ The mammæ are not always symmetrical. The gland rarely possesses two nipples. The left gland, according to W. B. Woodman, more commonly exhibits this peculiarity, it being commonly the larger.² At birth the mammæ resemble

¹ Luschka gives from twelve to fifteen lobules; Quain fifteen to twenty.

¹ Luschka's "Die Brust," 250, where reference is given to Roberts in Meckel's Path. Anat. der Brustdrüse. Illustr. Mediz. Zeitung., Munich, 1852, 142. See, also, A. H. Cameron, Journ. of Anat. and Phys., 1879; Ibid., J. M. Bruce, 425.

² Trans. Obstet. Soc. Lond., 1868, 51.

sebaceous glands, having a single duct. During childhood the ducts multiply, by which an increased growth of the entire gland is implied.

REMARKS.—The mammary gland is remarkable for the periodicity of its functional activity. In the foetus it assists in secreting the sebaceous matter (*vernix caseosa*) which protects the skin of the embryo from dangers of maceration. This phase of activity, as a rule, persists for a short time after birth, and may determine congestion and even suppurative inflammation about the nipple. During infancy (with the exception of the few days indicated) and childhood the glands are inactive, but in the female, toward puberty, they enlarge, and in the period extending between the fifteenth and the forty-fifth year are capable of assuming great increase in size and in function. After the forty-fifth year, at a time corresponding to the cessation of the menstrual period, the glands cease to secrete, and undergo atrophy of the cellular elements. At this period they are liable to incursions of morbid action, notably from carcinoma.

The lymphatics of the axilla are usually involved in advanced states of malignant growths. Galactoceles arises from the accumulation and retention of milk in the lactiferous ducts.

THE SKIN.

The Skin (integument, *cutis*¹) is a sheet-like elastic covering to the superficies of the body. It is designed to protect the delicate underlying structures, to permit of the exudation and absorption of liquids, to conserve animal heat, and to accommodate the organs of touch, the sebaceous glands, and the sweat-glands. The hair and nails are appendages to the skin which supports them.

The skin is composed of two great divisions, the dermic and the epidermic.

The *dermic* layer is subdivided into the papillary and the reticular layers; and the *epidermic* layer into the spinous, granular, lucid, and cuticular layers.

The Derm (true skin, *cutis vera*, *corium*) is composed for the most part of interlacing fibrous bands, which gives the skin in great part its thickness, and to which its protective value is due. It accommodates the papillæ, the sweat-glands, the sebaceous glands, the hair-follicles, and receives the bloodvessels, nerves, and lymphatics. The true skin is composed of two principal portions, which, however, merge into each other: a *papillary layer* (super-

ficial layer), which receives the papillæ, and is made up of a compact arrangement of fibrous tissue; and a *reticular layer* (deep layer), which is composed of coarser fibres; these fibres form reticulations for the retention of firm aggregation of fat-cells (*panniculus adiposus*). The reticular layer gradually passes into the fat of the subcutaneous connective tissue.

The papillæ are widely distributed, though they may be absent in some areas. They are best developed on the palms, the palmar aspects of the digits, the clitoris, the penis, the nymphæ, and the nipples, where they are elongated; upon the face they are shorter. They are well-developed in the negro (see Fig. 196).

The papillæ of the skin are small, short, conical, or sub-conical elevations of connective-tissue fibrillæ which accommodate the tactile corpuscles or loops of bloodvessels and lymphatic vessels. The papillæ vary in form; when several are united to a common base, the term *compound papillæ* designates them.

The papillary bodies are arranged in folds and ridges which are of great delicacy and intricacy. They are best developed upon the palmar surfaces of the fingers and the plantar surfaces of the toes. According to H. P. Bowditch, they are of constant value in the individual, and aid in the study of the identification of the body.

Fig. 196.



Horizontal section through the scalp of a negro. *R*, Spinous layer; *Pi*, row of columnar epithelium surrounding the papillæ; *Pa*, papilla cut transversely; *D*, papillary layer of the true skin.

The Epidermic Division is divided into four layers, as already mentioned, the spinous, the granular, the lucid, and the cuticular layer.—The *spinous layer* (prickle layer, mucous layer, rete Malpighii, stratum spinosum) is the deepest of the layers, and lies directly upon the papillæ. Near the true skin the cells of this layer are cylindrical in form. The cells throughout are remarkable for retaining numbers of

¹ See also, p. 37.

protoplasmic processes which, from the fact that they resembling prickles or spinous projections, has given them the name they bear. The cells of the spinous layer become flatter as they reach the surface.—Superimposed upon the spinous cells is the *granular layer* (stratum granulosum); above this the delicate *lucid layer* (stratum lucidum); and finally the flattened imbricated cells constituting the *cuticular layer* (see in extension, p. 37).—The cells of the granular layer and some of the spinous layer yield a peculiar substance which is called the *hyaline substance* of Recklinghausen (kerato-hyaline of Waldeyer). It probably serves a purpose in converting the cells of the epiderm into horn-substance, and thus aids in giving consistence to the hairs and the nails.

The muscles of the skin.—The skin is moved by muscular fasciculi inserted into it as in the instance of the Platysma Myoides, Palmaris Brevis, and the muscles of expression. The fibres of the skin can be moved upon themselves by intrinsic muscle-fibres. Such fibres are best developed in the scrotum where they constitute the *dartos*, but are also seen well developed in the nipple. No portion of the skin is entirely free from muscle-fibres, and they may be said to form two distinct groups: first, the group associated with the hair follicle (*Arrectores Pilorum*), which by their contraction can erect the hair and project slightly the walls of the follicles; and a second group called by Unna¹ the oblique tensors of the skin. The second group most probably acts in conjunction with the elastic fibres, and aids in maintaining the circulation of the blood and the lymph, as well as in facilitating the escape of sebaceous matter and sweat.

GENERAL CONSIDERATIONS OF THE SKIN.—In some localities, as in the scalp, the palms and the soles, the beds of the nails, the line of Poupart's ligament, the crests of the innominate bones, the auricles, the tip of the nose, and the eminences over the spinous processes of the vertebræ, the skin is held in various degrees of fixation.

Some of these depressions of the skin are determined by muscular action, and are noticed more especially in the face, the hands, and the feet. A number of depressions almost peculiar to the face result from the traction of muscles, and are seen as "furrows" and "wrinkles" as effects of inanition and of advancing years. Dimples are pit-like depressions at points where the skin is held down to subjacent parts

by delicate trabeculæ: the chin, the cheek, and the elbow exhibit them. They are most conspicuous in well-nourished persons in whom the adjacent integument is well cushioned in fat. The skin is everywhere thin in children, and possesses a relatively abundant subdermal connective tissue. As a result of this peculiarity furuncular abscess with these subjects involves the deeper parts to a greater extent relatively than in the adult. The cutis in the adult possesses an average thickness of from one-and-a-half to two mm. The skin is thinnest in the eyelids, the external auditory meatus, the lips, the glans penis, and the inner surfaces of the labia majora. It is relatively thin on the sheath of the penis, the scrotum, the nipple, and exceptionally thick on the palms and the soles, the buttock and along the back. The habitual use of clothing to some extent influences the general thickness of the skin.

The margins of orifices at which mucous membrane and skin join, and which are free from cartilage, as at the oral and the anal apertures, are thin and mobile, and are liable to special invasions of diseased action. Among these may be mentioned fissure, mucous patch, condyloma, and epithelioma. In congenital ichthyosis the orifices named are of defective development (see Variations).

The skin is extensile, and when divided retracts. Not merely are these properties due to the elasticity of the fibres of the derm, but are in a measure the result of action of muscular fibres in the skin. A given surface of skin may, under a gradual force exerted from beneath, adapt itself to a large area. Thus a tumor may acquire tegumental covering without the necessity of encroaching upon the skin of regions adjacent to that in which the growth originates. In the event of removal of the tumor the skin will not retract to its former dimensions, and is usually in part excised with the growth itself. As a sequence of pregnancy it may be mentioned in connection with this subject that the mobility of the anterior abdominal wall is increased, and its indisposition to retract to the proportions customary in women prior to the first pregnancy is impaired, hence the walls are more or less pendulous and exhibit peculiar lines which result from the strain and disrapture attending the pressure of the gravid uterus. In health the skin is adapted to the outline of the limbs; but in the emaciated and in the aged, folds of skin are conspicuous in many parts of the body from the inability of the skin to conform itself to the shrunken condition of the underlying tissues.

The adipose tissue which is so abundantly deposited

¹ *Infra*, 14.

beneath the skin in health, is closely incorporated with the skin in the buttoek, the palms, the soles, the lobes of the ear, and to the skin of the face, where it forms cushion-like masses to aid for the most part in the protection of the deeper parts against external pressure. The skin can be raised in folds from the subdermal structures in the neck, and in the greater part of the limbs, especially at the lines of flexion of the joints.¹

The presence of fat, when it is moderately firm, causes the skin to form transverse folds in some portions of the body, especially in well nourished infants and obese persons. The most prominent of these folds are seen in the neck, along the limbs; one lies across the abdomen on a line joining the anterior superior spinous processes of the innominate bones.

The presence of fat in the adult, taken together with the absence or presence of hirsute growth, is a valuable subordinate sexual character, and may be employed in the determination of the question of sex in the living subject.

Variations.—The skin is singularly inapt to be the seat of congenital defect, and with the exception of the absence of the skin over the abdomen in whole or in part, the absence over the region of the heart, and the absence over the region of the vertex, occiput, or region of the dorsal spine it may be said never to suffer from congenital deformities.—When the skin about the umbilicus is defective it causes the formation of umbilical hernia.

Dermatologists include among anomalies of the skin a number of affections of the epidermic portion. Congenital ichthyosis may be accepted as a type of such a condition, and in the judgment of E. Lesser² is a defect not only in the epidermic division, but of the skin of the body as a whole. The skin would appear to be arrested in growth, and the distending forces of development rupture it, thus forming large transverse fissures upon the trunk, longitudinal fissures on the limbs, and failures of development of the parts dependent upon a normal union of mucous and tegumental structures, as at the palpebral fissures, the mouth, and the anus. Such subjects perish within nine days after birth.

THE NAILS.

The Nails are flexible, translucent, horny structures which arise from the epidermic layer of the skin

upon the dorsal aspects of the terminal phalanges. Each nail is gently convex from side to side, and is thicker in the middle than at the edges. The nail presents a distal, free border, and fixed lateral and proximal borders. The border last named is called the *root*; the exposed portion, the *body*; the oval white space in advance of the root, the *lunula*; and the superficial structures, which aid in imbedding the nail, the *nail-folds*.—The surface upon which the nail lies and to which it adheres is called the *bed of the nail* (matrix). It is composed of a thin layer of spinous cells resting upon the true skin layer which is at this place rich in ridges bearing papillæ.

The nail is marked along its exposed portions by a number of faint, longitudinally disposed lines. When the nail is torn from its bed or allowed to fall away by maceration, the under surface is seen to be marked by numbers of more conspicuous lines. These consist of minute parallel striæ which are ranged in a single series over the entire surface, and which correspond in position to the ridges of papillæ of the nail-bed.

The *nail-folds* (perionych, eponychium) are best seen in section.

When section of the digit is made from above downward, the root of the nail is seen to lie between the bed and a triangular portion of epiderm, which is composed, first, of a thin layer of ectele lying against the nail; second, a layer of granular cells, and third, a layer of spinous cells.

The nail-folds have been named the *eponychium* by P. Unna,¹ who, under this name, describes a layer of epiderm belonging to the true skin and which envelops the nails in foetal life. It is homologous with the "epitrichium" of the sloth-type of mammal. The eponychium is represented in the life-history of the phalanx by the thin translucent fold of epiderm, which exhibits a disposition to leave the derm, and, adhering closely to the nail, to advance along it from the root upon the dorsal surface. The eponychium is frequently lacerated, and when drawn forcibly backward irritates the skin and exposes the subepithelial structures. Such tags of tissue are popularly known as "hang-nails," and are the localities at which syphilitic virus and other forms of animal poisons frequently have entered the system.

REMARKS.—The nails are delicate clinical tests of nutritive changes. Dr. S. Weir Mitchell has ascertained that they cease to grow in paralysis. In relapses of typhoid fever the nails also cease to

¹ The lines of flexion of the joints, the median aspect of the limb, and the inferior aspect of the trunk are the parts most protected in the embryo. They are also the parts that answer to the most protected surfaces in quadrupeds. It is interesting to note the indisposition of ichthyosis to involve these regions, and the activity of gland secretion within them.

² Ziemssen's Handb. d. special. Path. u. Therap., xiv. i. 1883, 479.

¹ Ziemssen's Handbuch d. special. Path. u. Therap., xiv. i., 39.

grow, but they renew their activity as convalescence progresses. G. Rolleston¹ has recorded a curious condition of the nails in cyanosis. Dr. J. M. Da Costa has demonstrated the utility of examination of the nails in doubtful cases of typhoid disease, with a view of determining the lines of growth-cessation of the nail. The transverse line of death is opaque white, the line of growth a translucent pink color.²

The form of the nail varies according to general conditions of nutrition. It is highly arched or clubbed in slow wasting disease, an appearance which was at one time thought to be characteristic of phthisis.

In some forms of cyanosis the ends of the fingers have a tendency to whitlow.³

In subclavian aneurism the finger ends of the corresponding hand have been observed by A. Poland to be somewhat clubbed in shape, and cold and moist to the touch. The nails may be desquamating and of a dark-purplish color.⁴ In a case of subclavian aneurism recorded by Langenbeck,⁵ a peculiar condition of the finger ends was reported as occurring at the time

when a recurrent increase of the aneurism took place, after having been quiescent for a period of three years and apparently disposed to subside spontaneously.—Suchard¹ has made a series of careful studies of the nails in diseased conditions.

Errors of nail-growth correlate with similar errors in the development of the teeth, and it is probable that the milky spots in enamel are the effects of temporary arrest of development in the enamel-organs during the process of the evolution of these structures. The nails of the first, second, and third fingers are more apt to exhibit the defects than are the nails of the fourth and fifth fingers, and all the fingers of the hands are more frequently affected than are any of the toes.

Excessive growth of hair is often associated with supernumerary growth of the teeth and hypertrophy of the mucous membrane of the oral cavity.

For an account of the Hair Follicles, the Hair, and the Glands of the Skin, see p. 43.

SUPERFICIAL AND TOPOGRAPHICAL ANATOMY.

SUPERFICIAL ANATOMY OF THE HEAD AND FACE.

The form of the skull can be easily determined by examination of the overlying soft parts. The position of the occipital, parietal, and frontal bones can be outlined as these structures enter into the vertex, and while in the infant the edges of the anterior and posterior fontanelles can be felt, the depressions answering to their former positions can be ascertained through the period of adolescence in those subjects in whom growth has been slow.

The more common bony prominences which can be detected in the undissected subject are the following: the occipital protuberance, the superior semicircular line (inconstant), the temporal crest, the mastoid process, the external angular process of the frontal bone, the malar bone, the margins of the orbit, the superciliary ridges, the boundaries of the anterior nasal aperture, the zygomatic arch, and the nasal eminence. Within the mouth the incisorial and the canine fossæ,

the hard palate, the beginning of the mylo-hyoid ridges, and the pterygoid processes of the sphenoid bone can be determined. With the finger placed above the soft palate (see p. 150), the region of the true base of the skull can be felt, as well as the vomer as it aids in defining the posterior nares. The finger thrust up the nasal chamber from in front can ordinarily define the anterior end of the inferior turbinated bone and the under surface of the middle turbinated bone. The septum of course can also be distinguished.

Among the more important relations by which can be made out external signs are the following: the great longitudinal sinus lies beneath the position of the sagittal and frontal sutures from the nasal eminence of the frontal bone and the production of this line backward as far as the occipital protuberance. The position of the lateral sinuses corresponds to horizontal lines drawn from the position of the protuberance last named to the bases of the mastoid processes. The junction of a vertical line extended upward from a point behind the zygoma with a horizontal line extended backward from the external angular process of the frontal bone indicates the position of the great

¹ Nat. Hist. Rev., 1861, 488.

² Trans. Coll. of Physicians of Phila., iii., 1876.

³ C. E. Hasse, An Anat. Descrip. of Diseases of the Organs of Circulation and Resp. (Syd. Soc. Trans.), 178.

⁴ Med.-Chir. Trans., lii. 296.

⁵ Berliner klin. Wochenschrift, March, 1859, No. 12.

¹ Arch. Anat. et Physiol. norm. et pathol., n. s., x., 1862, 445.

meningeal artery where it is liable to bleed from fracture of the skull.

The fissure of Rolando, at and near the vertex, lies an inch and three-quarters to three inches behind the bregma (see p. 145). The distance is a little greater in males than in females. The lower limit of the fissure can be determined, according to Champignonnière, by extending a horizontal line backward from the base of the external angular process of the frontal bone, which is intersected by a vertical line two-and-three-quarter inches (seven cm.) in length. At the end of this line a vertical line is drawn, upon which, at a distance of one-and-a-quarter inch (three cm.), the lower limit of the fissure is reached.—The external part of the parieto-occipital fissure lies directly beneath the lambdoidal suture. The horizontal limb of the fissure of Sylvius extends parallel to the squamoso-parietal suture, about two inches above the zygomatic arch.

The anterior extremity corresponds to the pterion (see page 145). The frontal lobe lies in front of the bregma. The parietal lobe lies between the line of the fissure of Rolando and the lambdoidal suture. The occipital lobe lies between the lambdoidal suture and the external occipital protuberance. The sphenotemporal lobe lies below a line produced posteriorly from the base of the external angular process of the frontal bone. The position of the region of Broca is indicated by a horizontal line extended backward from the base of the external angular process of the frontal bone two inches (five cm.) in length. The posterior part of the third frontal convolution is situated nine lines (two cm.) above the posterior end of this line.

The lines mentioned being determined on the side of the head, the position of any desired portion of the cortex can be ascertained with an exactness sufficient for clinical purposes.¹

The *skin* of the face is, with the exception of that over the Buccinator muscle, the eyelids, and the bridge of the nose, adherent to the parts beneath. Hence the creasing and the wrinkling of the skin accompanying the contraction of the facial muscles. The eyelids are remarkable in being free from fat.—The skin can be pushed up or down some distance from the line of the lower jaw. It recovers readily from injury, and disfiguring scars are of infrequent occurrence.

¹ The foregoing section is epitomized from Tillaux. (*Traité d'Anat. Topogr.*, 63.) A more elaborate account is framed by E. Gavoy (*Atlas d'Anat. Topogr. du Cerveau*, etc., Paris, 1882, 149). See also a succinct statement based on research by W. Turner (*An Introduction to Human Anatomy*, Edinburgh, 1877, 266).

In the event, however, of the entire depth of the soft parts becoming involved in an ulcerative process (such as is seen in some forms of mercurial stomatitis, in cancerum oris, in burns of the third degree), facial scars are exceptionally dense and immobile; the pliable skin from adjacent places, as the skin of the neck, and even from the anterior chest-wall, may be dragged up toward the cicatrized locality.¹

The following bursæ, according to C. B. Nancrede,² can be located in the region of the head and face: over external occipital protuberance; temporo-maxillary articulation; at lower border of the chin; behind the Zygomaticus Major; an extension of the bursa last named passes beneath the anterior border of the Masseter muscle and comes into relation with a second bursa placed close to the coronoid process. Under certain circumstances these bursæ may extend to the base of the cranium. In the judgment of Nancrede,³ certain rare cysts of the cheek, which may extend to the base of the cranium, probably arise from an enlargement of these bursæ.

THE SUPERFICIAL ANATOMY OF THE NECK.

The Neck is divided by two lines drawn from the anterior borders of the mastoid processes downward to the shoulders into two sub-regions. That region in front of the lines is the anterior cervical region, and that back of them the posterior cervical region.

The Anterior Cervical Region is divided into three regions: a median, and two lateral. The plan of these regions and their subdivisions is as follows:—

	{	Supra Hyoid Region.
	{	Sub-Maxillary Region.
Median Cervical Region.	{	Infra-Hyoid Region.
	{	Sterno-Mastoid Sulcus.
	{	Carotid Triangle.
Lateral Cervical Region.	{	Retro-Maxillary Region.
	{	Sterno-Mastoid Region.
	{	Supra-Clavicular Region.

The Median Cervical Region has been compared to the figure of a kite, *i. e.*, to one composed of two truncated triangles, placed end to end, at their bases. The line of the hyoid bone represents the union of the bases of the triangles, the upper triangle forming the *supra-hyoid region*, and is defined above by the lower border of the inferior maxilla, and at the sides by the lines of the anterior bellies of the Digastric muscles. The

¹ See also Remarks on pp. 250, 252.

² *International Encyclopedia of Surgery*, ii. 1882, 705.

³ *Loc. cit.*

lower triangle, known as the *infra-hyoid region*, is defined below at the sides, by the median borders of the Sterno-Cleido Mastoideus muscles, as they approach the sternum.

The Supra-Hyoid Region (hyo-mental) is best seen when the head is thrown back, but best examined by palpation when the head is brought forward. It defines the space between the lower jaw and the hyoid bone.

The Sub-Maxillary Region. When the head is slightly inclined forward, this region lies on a nearly horizontal plane, and its lower limit is readily defined, for in this position the body of the hyoid bone can be readily felt beneath the skin. The central part of the region answers nearly to the position of the Genio-Hyoid muscles. These muscles can be felt to contract beneath the finger in the first act of deglutition and in the pronunciation of the letter V. The position of the sub-maxillary salivary glands, and not infrequently the superficial sub-maxillary lymphatic glands, and the anterior bellies of the Digastric muscles, can be determined.—The *skin* of the sub-maxillary region is loose to permit the free motion of the head and of the lower jaw. It is more fixed at the border of the under surface of the chin than elsewhere. At the sides two conspicuous folds of skin are seen in the aged. The skin can be drawn up toward the face, and in the cicatrices resulting from burns the tractile force may be sufficient to depress the lower jaw. The sub-maxillary region is of surgical interest, since it is here that the floor of the mouth is opened in amputation of the tongue, and that pus gravitates from deep-seated abscess of the lower jaw.

The Infra-Hyoid Region (jugular region, nearly) in a strict sense represents the front of the neck when the face is directed forward. Beneath the skin can be felt the prominence of the thyroid cartilage. In females and in children the prominence of the thyroid cartilage is absent, and in the former may be lost in the even convex surface of the neck.

In addition to the foregoing are noticed the cricoid cartilage, the thyroid body, with its incisure, and the beginning of the trachea. The upper border of the thyroid cartilage can be determined, as well as the space between this cartilage and the hyoid bone. The lower part of the infra-hyoid region (sulcus sterno-mastoideus) is defined by the median borders of the Sterno-Cleido-Mastoideus muscles at the sides, and the supra-sternal notch below. The parts lying within these boundaries are not, as a rule, detected from

without. They represent the trachea, fascia, and fat. In children the innominate artery can be felt pulsating in this space.—The *skin* of the infra-hyoid region is very movable to enable the laryngeal and tracheal apparatus free play of motion. Care should be taken to fix the skin in making incisions in this region. This is more particularly of importance in the performance of tracheotomy. The branches of the external jugular and anterior jugular veins are conspicuous in this, and in the lateral cervical regions. Conspicuous among the superficial structures of the neck which may have clinical interest, is the bursa surrounding the tendon of the Digastric muscle. Bursæ are also lodged between the skin and the neighborhood of the thyroid cartilage; these have received the names of ante-thyroid, infra-hyoid, and supra-hyoid bursæ.

The Sterno-Mastoid Sulcus (carotid region, nearly).—A shallow groove lies between the Sterno-Cleido-Mastoideus muscle, the larynx, and the trachea. It is continuous above with the retro-maxillary fossa, and below is lost in the jugular region. That part of the recess which lies between the median and lateral structures of the neck is of special interest, since it transects the line of the greater cornu of the hyoid bone, and has received the name of the *carotid triangle*; and that part which lies between the trachea and the median border of the Sterno-Cleido-Mastoideus has received the name of *sterno-mastoid sulcus proper*.

The Carotid Triangle (trigonum carotideum) is broader and deeper than the remaining portion of the groove, and corresponds to the position of the common carotid artery, as this vessel is about to divide into the internal and external carotid arteries. The term carotid triangle is derived from the circumstance that in dissection the median border of the Sterno-Cleido-Mastoideus, the line of the posterior belly of the Digastric, and the line of the anterior belly of the Omo-Hyoid muscles define it. The triangle, in a study of surface-anatomy, is chiefly interesting for the marked pulsation which is distinguishable here. In many conditions of health, particularly in the anemic condition of females, which verge toward or are identified with exophthalmic goitre, the pulsations are very decided. It is here that the arteries are known occasionally to enlarge in calibre (see p. 366), and it would be an interesting point to determine, in subjects in which such enlargements occur, the ante-mortem conditions with which the swellings were coincident.

The infiltrations attending acute laryngitis and pharyngitis may so change the relations of the vessel in the carotid triangle as to lead the incautious in examining the superficies to mistake the vessel for an engorged lymphatic gland.

The Lateral Cervical Region embraces the neck between the Sterno-Mastoid sulcus and a line produced from the mastoid process. It is chiefly remarkable for the conspicuous prominence at its upper two-thirds, which is caused by the belly of the Sterno-Cleido-Mastoideus muscle, and for the depression behind the lower jaw and above the clavicle.

The Retro-Maxillary Region is the space beneath and behind the prominence formed by the angle of the jaw. The depression above and behind the lobule of the ear is called the *sub-auricular fossa*. The region is defined posteriorly by the mastoid process. The transverse process of the atlas can sometimes be felt at the base.—The *skin* of the retro-maxillary region is everywhere lax, and permits the finger to define the inner contour of the angle of the jaw. The lower lobule of the parotid gland can be felt in some subjects.

The upper portion of the region has received the name of the Sterno-Mastoid region, and embraces the origin and belly of this muscle the greater part of its length.—The pus from a mastoid abscess has been known to flow into the digastric groove of the temporal bone, and following the occipital artery and the posterior belly of the Digastric muscle, to diffuse itself through the deep tissues of the neck beneath the Sterno-Cleido-Mastoideus muscle.¹

The Supra-Clavicular Region embraces the region immediately above the clavicles between the opposed borders of the Trapezius and Sterno-Cleido-Mastoideus muscles. The recess near the outer portion of the bone is of interest from the fact that it is in this fossa that the third portion of the subclavian artery can in some individuals be found pulsating, and within this fossa the first incision is made in the operation for ligation of the subclavian artery at its outer third.—Numbers of lymphatic glands are present in the supra-clavicular region.—The process of the cervical rib can sometimes be detected here.²

The apex of the lung enters into this region, and it

also receives the trunk of the external jugular vein. The pulsation of the transverse cervical artery can sometimes be distinguished in the supra-clavicular fossa.

The Posterior Cervical Region.—The *skin* of this region is thick and leathery. In backward traction of the head it is thrown at its upper part into a number of parallel transverse folds. Above, where it merges into the scalp, it is rich in hair follicles, and in sebaceous and sweat-glands. The subcutaneous connective tissue is abundant, compact, and occupied by trabecular bands holding the skin to the associated bones and muscles. It is a common site for painful forms of furuncle and carbuncle, and yields occasionally the nidus of origin of pedunculated fatty tumors which may attain enormous size. If the line of the lower border of the inferior maxilla be produced backward, it will cross the posterior cervical region at a point which answers to the position of the transverse folds just mentioned, and will serve as the inferior border of the *nape of the neck*, the superior border of which space corresponds to a line crossing the occiput just below the occipital protuberance.

A conspicuous fossa (fovea nuchæ) is ordinarily defined in the nape of the neck between the muscular elevations corresponding on each side to the upper portion of the Complexus and Biventer Cervicis muscles, and the thin overlying Trapezial sheet. The fossa is best defined in children from the fifth to the twelfth year; it is least conspicuous in obese male adults, and may be entirely absent in women. The bottom of the fossa answers to the space between the occipital bone and the arch of the axis, and includes the posterior arch of the atlas. From its relation to veins as they pass out from the brain-case, and to the pharyngeal plexus it is the favorite locality for the application of cups.

The posterior surface of the neck below the nape answers to the upper part of the lozenge-shaped membranous intersection of the Trapezii muscles.—The spines of the cervical vertebræ are not felt beneath the skin until the seventh cervical is reached.

A bursa which may become sufficiently large to attract the attention of the surgeon is lodged over the spinous process of the seventh cervical vertebra.

THE SUPERFICIAL ANATOMY OF THE CHEST.

The Chest is that part of the trunk whose framework is secured from the thorax.

¹ Fr. Berzold, Deutsche Med. Wochenschr., No. 28, 1881; see also Am. Jour. Otol., iv. 1882, 146.

² T. J. Shepherd, Am. Journ. Med. Sci., clxix., N. S. 1883, 112 (fig. and literature).

It presents for examination—¹

The Anterior Thoracic Region.

The Posterior Thoracic Region.

THE ANTERIOR THORACIC REGION.—The anterior aspect of the chest is continuous with the median surface of the upper extremity by the line of distribution of some of the nerves and lymphatic vessels common to both localities, *e. g.*, the intercosto-humeral nerve, and by the range of the lymphatic trunks from the arm to the sides of the chest at the axilla.

For convenience in description, any line desired for purposes of description in locating a wound, a growth, distribution of eruptions, or for other clinical purposes, can be referred to a line drawn downward from the sternal, middle, and acromial portions of the clavicle, or at any intermediate point. Thus the guides to the superficial anatomy of the chest are three in number, the clavicle, the sternum, and the ribs.

The *clavicle* constitutes the most important of these guides. It furnishes a main line—the *mammary line*—which is drawn downward from the clavicle in such direction as to traverse the front of the chest through the nipple.

The *sternum* affords a median line for the anterior thoracic region, to which bilateral parts can be referred. This line is of especial use in reporting results of post-mortem examinations, and in locating tumors in the anterior mediastinal space.

The *ribs* are very generally used in locating clinical conditions. The determination of the ribs from above downward, aided by the position of the sternal line and of the clavicular line, will give any selected locality with sufficient exactness. The *axillary line* of Couradi extends from the origin of the *Scalenus Posticus* to the free end of the tenth rib.

The anterior thoracic region is divided into various divisions which are purely arbitrary in character, and need not be here outlined. Among the localities which are sufficiently well defined for the most part by the titles, are the *sternal region*, which corresponds to the position of the sternum (sterno-costal region); the *infra-clavicular region*, which answers to the space bounded above by the lower margin of the clavicle, and below by a line extended horizontally outward from the upper margin of the sternum, and which at its lateral limit corresponds to the summit of the axillary space; the *mammary region*, which answers to the position of the mammary

gland; and the *infra-mammary region* (diaphragmatic region, nearly), which extends from the lower margin of the *Pectoralis Major* in the male, and from the lower border of the mammary gland in the female, to the ninth rib.

The *skin* of the anterior thoracic region is much thinner than the posterior. It is tense and but slightly movable over the sternum, and presents, when compared with the skin of other regions, low reparative power. The lips of an incision made in this region tend markedly to separate one from the other. In caries of the sternum the skin is inflamed, and may be ulcerated to an extent almost equalling the surface involved by the disease itself. The skin over the mammary region increases in delicacy as it approaches the nipple, and becomes darker in color. It is apt to be fissured in lactating women. A number of the diseases of the nipple have their origin in the same peculiarity of the skin. Thus the nipple is liable to eczematous affections, and to a peculiar form of cancerous involvement. The skin of the mammary region is smooth in the child and in the virgin, but becomes wrinkled in the woman who has borne children.—At the sides of the chest, namely, about the parts traversed by the axillary line, the skin, owing to the lines of traction of the *Pectoralis Major*, *Pectoralis Minor*, and *Latissimus Dorsi* muscles and the scapula, is very mobile. The course of the superficial nerves as they pass obliquely downward and forward on the side of the chest is outlined by crops of vesicles in herpes zoster.

The structures which can be located beneath the skin are liable to some variation according to the age and the condition of health of the subject. In average states of the adult the anterior surface of the sternum can be outlined as well as the costal cartilages; the ribs can be also felt. The most conspicuous muscle is, of course, the *Pectoralis Major*; next in order appear the fifth, sixth, and seventh digitations of the *Serratus Magnus*. The landmarks of the lower portion of the chest, especially at the sides, also vary, particularly in females, in which class of subjects the lower ribs are often distorted by long-continued use of corsets.—Jacobi¹ has directed attention to a bursa over the xyphoid cartilage in rachitic children.—Of the mammary gland, and the lower border of the thorax and attached muscles, see the accounts of this gland and the thorax.

The Posterior Thoracic Region is naturally a part of

¹ Richet divides the chest into the main divisions of sternal or anterior wall; costal or lateral wall; and diaphragmatic wall.

¹ Am. Journ. Obstet., 1875, viii. 165.

the general surface of the "back," but is less sharply defined than either the posterior cervical region or the loin. It may be said to lie posterior to the axillary lines; below a line drawn transversely across the neck beneath the seventh cervical spinous eminence; and above a line drawn transversely one-half inch beneath the free ends of the tenth ribs. It will be observed that neither of the lines last named is exact, since the upper line does not strictly correspond to the position of the clavicle, while the lower omits the eleventh and twelfth ribs. But the twelfth rib at least cannot be constantly felt from behind.

The parts that can be distinguished in the back are the contour of the Erector Spinae muscles; the groove-like depression (spinal furrow) answering to the spinous eminences lying between these muscles; the fleshy eminence due to the Latissimus Dorsi and Teres Major muscles as these muscles lie along the axillary border of the scapula; the spine and angle of the scapula; and the depression for the attachment of the lower set of Trapezial fibres to the bone last named.

The *skin* on the back of the chest is thick and brawny. It is loosely connected to the muscles and fascia, as a result of which peculiarity a ball, or other missile, lodged beneath the skin of the back, possesses a tendency to gravitate, and may be found lying just above the sacrum. Bedsores often occur on the back over the position of the scapulae, and at the lower median portion. The pressure of burdens may cause bursae to appear over the dorsal spine and the Supra-Spinatus muscles. For "landmarks" of the scapula and the vertebral column, see p. 172 and p. 166.

The *axilla*¹ (armpit), while belonging in part to the anterior and in part to the posterior thoracic region, is usually treated of as a separate region. It constitutes that triangular space whose summit (apex) lies at the junction of the skin over the second rib with the median surface of the arm; whose sides are formed respectively by the Pectoralis Major and the Latissimus Dorsi and Teres Major muscles; and whose base answers to an imaginary line uniting these muscles. The lower border will of course vary in different subjects. In a general way it may be said to answer to the line of the fourth rib.

The axilla is best defined when the arm is elevated. It is here that the intercostal spaces are readily outlined, since the ribs do not lie so near one another as

at points lower down, *e. g.*, between the seventh and tenth ribs, where they may be almost, if not quite, contiguous. Lymphatic glands when moderately enlarged can be felt beneath the skin in the armpit. They are at this place frequently engorged in carcinoma of the mammary gland and in inflammation of the lymphatic vessels of the arm.

The *skin* of the axilla is mobile and furnished at the summit with a clump of long hairs. Both sweat-glands and sebaceous glands are well developed in this region.

THE SUPERFICIAL ANATOMY OF THE ABDOMEN.

The trunk between the chest and the pelvis is conveniently divided into two portions which are comparable to the anterior and posterior regions of the neck and chest. The anterior region forms the "anterior abdominal wall;" and the posterior region the "loin."

The Anterior Abdominal Wall.

The Loin.

The Anterior Abdominal Wall¹ extends from the lower margin of the thorax to the iliac crest and the line of Poupart's ligament. Laterally the region ex-

¹ This surface will correspond to the antero-lateral region of Angers and Tillaux, and the two regions of Richet, the anterior and the lateral region of the abdomen. Clinical reports rarely locate conditions in any other region than those outlined on p. 736.

A natural subdivision of the anterior wall of the abdomen might be based upon the following statements:—

The integument of the anterior surface of the abdomen is continuous with that of the inguinal regions, the pudendal regions, and the median surfaces of the thighs by the distribution of some of the anterior branches of the dorsal and lumbar nerves among the last named, the ilio-hypogastric, the ilio inguinal, and the genito-crural nerves. From the position of the umbilicus upward it is controlled by the intercostal nerves, from the eighth to the ninth inclusive; while below the umbilicus it is controlled by the tenth to the twelfth inclusive, together with the anterior branches of the ilio-hypogastric and the ilio-inguinal nerves.—The umbilicus is situated on a line which answers to the middle and most constant of the inscriptions of the Rectus muscle, and about on a second line which answers to the production downward and forward of the eleventh rib. When it is remembered that the ductus venosus extends from the umbilicus upward to the liver, and that the bladder and urachus, from the pubis upward toward the umbilicus, it must follow that the best division of the abdominal wall would be into two portions, a supra-umbilical and an infra-umbilical, and that the subdivision of these regions should be along the oblique lines which correspond to the position of the floating ribs and of the nerve-tracts of the abdomen.—The proportions of the fetal liver near term would bring this most bulky of the organs of the upper belt well down to the position of the umbilicus, and in the fetus at term, at least, the abdomen might be divided with propriety into an upper and lower belt, the middle being discarded.—In the arrangement of the regions, the plan of Bright (Guy's Hosp. Rep., ii. 1837, 432) has been followed in the text, and the language of this writer, as far as was practicable, used.

¹ It is necessary to remember that the term "*axilla*" is here restricted to the superficies.

tends to the median border of the *Quadratus Lumborum* and to an imaginary line drawn upward from the process which answers to the posterior border of the anterior dorsal concavity of the innominate bone.

The right and left portions are so united in the median line that it is exceptional for a morbid involvement of one side of the abdominal wall to pass over to the parts of the opposite side.—The walls are pierced obliquely at the lower boundary by the inguinal canals, and in the foetus by the umbilical cord.

The anterior abdominal wall is divided arbitrarily into nine regions, as follows:—

Upper Belt	{	The Epigastric,
	{	The Right Hypochondriac,
	{	The Left Hypochondriac.
Middle Belt	{	The Umbilical,
	{	The Right Lumbar,
	{	The Left Lumbar.
Lower Belt	{	The Hypogastric,
	{	The Right Inguinal,
	{	The Left Inguinal.

The Epigastric and Hypochondriac regions form a natural division of the anterior abdominal parietes, inasmuch as they aid in inclosing that portion of the abdomen which is controlled by the form of the thorax. The skin of the chest passes without fold or crease into the belt just outlined, receives nerves from the same sources as the lower portion of the chest-walls, and protects organs which at the same time secure additional protection from the lower ribs, the sides of the Diaphragm alone intervening. All its organs tend to ascend in expiration and descend in inspiration, and in morbid conditions can in many instances be determined by palpation and pressure of the lower chest walls as well as of the walls of the abdomen. This portion of the abdomen is sometimes called *epigastric*, although later custom has restricted this term to the middle part only.

The upper boundary of the upper belt is the Diaphragm; the lower boundary is an imaginary line drawn between the anterior extremities of the tenth ribs. The cartilage of the tenth rib forms ordinarily a distinct projection. A horizontal plane carried backward from the line will pass between the bodies of the first and second lumbar vertebræ, and emerge posteriorly at the lower edge of the spinous process of the vertebra first named.

The upper boundary of the upper belt, being formed by the Diaphragm, varies in its position at each effort of respiration. Anteriorly, it corresponds with the junction of the xyphoid cartilage with the sternum; but from this point it will be found to

deseend from before backward toward the spine, and on either side toward the ribs, until it reaches the lower boundary of the belt.

The Epigastric Region (*scorbigulus cordis*, *præcoridium*). This region is broader below than above, and contains the whole of the left lobe of the liver and a part of the right, together with part of the gall-bladder, the ducts, hepatic vessels, Glisson's capsule, the pyloric end of the stomach with the commencement of the duodenum, a portion of the transverse colon, the pancreas, the abdominal aorta, and the celiac axis, with the inferior cava and superior mesenteric artery.

The Right Hypochondriac Region. This region contains nearly the whole of the right lobe of the liver, the hepatic flexure of the colon, and a small portion of the right kidney with the corresponding supra-renal capsule.

The Left Hypochondriac Region. This region contains the rounded cardiac portion of the stomach at all times; but a very large part of that organ when distended, the splenic flexure of the colon, the spleen, and a small portion of the left kidney with the supra-renal capsule.

The right hypochondriac, the epigastric, and the left hypochondriac regions are in a measure separated from the remainder of the abdomen by the transverse mesocolon. In many clinical studies such tendencies are found emphasized by the presence of bands of peritoneal adhesions. In this, the upper portion of the abdomen, are suspended the most numerous and bulky of the abdominal viscera. Diseased action is frequently herein localized, not only in the interior of the several organs, but in their interspaces as well, as between them and the abdominal walls or the intestines.

C. Hilton Fagge has analyzed a number of cases of abscess exhibiting such localization, and finds the cases susceptible of division into two groups: (1) those in which an abscess is situated in the right hypochondrium, lying between the liver and the Diaphragm; and (2) those in which the affected region is the left hypochondrium, pus having formed in a cavity bounded by the spleen, the stomach, and the Diaphragm. These cases have a tendency to terminate fatally by involving the pleura by direct transmission of the inflammatory process, or by rupturing the Diaphragm and creating a secondary empyema.

In one instance of an abscess, which was apparently a sequel to cancerous involvement of the gastric pylorus, the pus had accumulated in a space in advance of the liver, below the Diaphragm, and behind the anterior abdominal wall. It was prevented from gra-

vitating and involving the peritoneal cavity by adventitious adhesions, which extend from the pylorus to the anterior wall of the abdomen. In a second case the pus was due to disease in the pleural sac, directly through the Diaphragm.

Collections of pus may form about a ruptured spleen, and involve the retro-peritoneal space. Such abscesses may invade the tissues both in front and behind the œsophagus, and press the kidney and supra-renal capsule downward and inward. In another instance of abscess in the left hypochondrium and epigastric region, Fagge determined that the pus had found its way into the transverse colon. In yet another, the stomach was adherent by its cardiac end to the spleen, the latter organ being fixed in its turn to the Diaphragm and the kidney. The pus had entered the capsule of the spleen, and partially involved the kidney.—For involvement of the upper belt by wandering gall-stones, see p. 672.

The Middle Belt includes the umbilical, the right lumbar and the left lumbar regions.

The Umbilical Region.—The umbilical region is bounded above by the lower epigastric plane, and below by a horizontal plane passing through the anterior superior spinous processes of the innominate bones. This plane, if produced backward, will cut the centre of the second portion of the sacrum on the anterior surface of the bone, and emerge posteriorly between the second and third sacral spines.

The umbilicus lies on a horizontal line; this line is near the level of the highest point of the crest of the ilium, and it answers to the anterior edge of a plane the posterior edge of which bisects the vertebral column at about the third dorsal vertebra.

The umbilical region is chiefly occupied by a portion of the transverse colon, the omentum, and the small intestines; and it contains, likewise, the mesentery and its glands, the abdominal aorta, and the inferior vena cava.

T. W. King¹ describes a case of a child, fourteen months old, in whom a feculent umbilical discharge appeared, which, in the judgment of the reporter, came from a diverticulum of the intestinal tract. The opening closed after a treatment of six weeks. A second, but fatal case, is narrated in the same communication.

Intramural abscess of the abdomen, when not due to perityphlitis, is most commonly situated in

the umbilical region. Such an abscess has been occasionally detected in children and adolescents. Instances are on record of collections thus originating, dissecting between the peritoneum and the muscular layer over the greater part of the anterior abdominal wall.¹

The Right Lumbar Region.—The right lumbar region is subdivided into the lumbar region proper, and the iliac fossæ. It contains the upper part of the cæcum, the ascending colon, the lower and middle portion of the right kidney, the ureter, and a portion of the Quadratus Lumborum and of the Psoas Muscle.

The Left Lumbar Region.—The left lumbar region is subdivided, as is the right, and is occupied by the descending colon, and chiefly in the iliac fossa, by the sigmoid flexure, part of the left kidney, and the ureter.

The small intestines likewise occupy the lumbar regions on either side, and cover the ascending and descending portions of the colon.

The Lower Belt.—The lower belt includes the hypogastric, and the right inguinal and the left inguinal region.

The lower belt (hypogastric portion) is the smallest of the three. It is bounded above by the lower umbilical plane, and below by the upper margin of the pubis in the centre, and Poupart's ligament on either side; the latter forms two divergent lines extending from the spinous processes of the pubis upward and outward to the anterior superior spinous processes of the innominate bone. This region, according to Bright, may be said to be extended into the hollow of the true pelvis occupying its whole cavity.

The cavity of the abdomen may be said to terminate at a line a little above Poupart's ligament, where the peritoneum becomes reflected from the fascia transversalis in front, on to the fascia iliaca behind, thus rendering the inguinal regions of the belly smaller from above to below than its external boundaries would appear to indicate.

The Hypogastric Region.—The hypogastric region (pubic region) contains the urinary bladder with portions of the ureters, the first portion of the rectum, and sometimes a projecting convolution of the sigmoid flexure of the colon, together with some portions of the small intestines, more particularly the

¹ Guy's Hosp. Rep., 1843, 467 (figs.).

¹ See J. Manley, London Med. Gaz., n. s. xviii., 1851, 139, 185.

lower convolution of the ileum, and, in the female, the uterus and its appendages.

The transverse line extending across the abdomen between the anterior superior spinous processes of the innominate bones lies just above the supra-pubic fat, and is probably determined by the position of the bladder which lies immediately behind it. This line determines the upper limit of a region which is sometimes called *supra-pubic*. Within this region the high operation for lithotomy and the high puncture of the bladder are performed.

Below the supra-pubic space is the *prevesical space* (space of Retzius) which is defined in the triangular interval between the symphysis pubis, the bladder, and the peritoneum. It is occasionally the seat of abscess.

J. E. Pilcher¹ describes an intramural space, which lies between the Recti muscles and the transversalis fascia, as the *sub-muscular space*, and as distinct from the pre-vesical space. It is occasionally the seat of abscess following strain of the Recti muscles.

The Inguinal Regions are very limited. They comprise but a small extent of surface, and are likewise exceedingly shallow in consequence of the approximation which here takes place between the anterior and posterior abdominal walls previously to their union at Poupart's ligament.

The Right Inguinal Region.—The right inguinal region sometimes contains the lowest part, or *cul de sac*, of the caput coli, and the vermiform process and the iliac vessels. The walls of this region are liable to involvement from perityphlitis.

The Left Inguinal Region.—The left inguinal region contains a part of the sigmoid flexure and the iliac vessels of that side.

"Assuming the foregoing as the regions into which the abdomen may be divided, it is evident that they will not correspond exactly with the extent and form of the different viscera; but that one division will often contain portions of several viscera, and one viscus will occupy portions of several divisions. Generally speaking, however, the position of the different organs will be as follows:—

"The upper belt will contain in its whole length the liver with the gall-bladder, the stomach, the contents of Glisson's capsule, the two colic flexures and part of the transverse colon, the duodenum, the spleen, the pancreas, the renal capsules, and a portion of each kidney, together with the aorta, the cava, the celiac

axis, and the commencement of the superior mesenteric artery.

"The umbilical and hypogastric are each divided into three regions, by two ascending planes passing directly backward, and drawn through the spinous processes of the pubis and the points on the tenth ribs, already alluded to as marking the lower epigastric plane. These planes diverge from each other; and if continued over the chest, will pass rather to the outside of the nipple in the male, until they reach the clavicle, not far from its acromial extremity.

"The umbilical subdivisions thus produced consist of a central region, which retains the name of umbilical, and two lateral regions. These last may be again divided into the iliac fossæ below, corresponding with the venter of the ilium."¹

THE LOINS.

The Loins (lumbar region, "small of the back") is the large square region which answers to that portion of the back which lies between the crests of the innominate bones and the lower margin of the chest. With reference to the regions of the anterior abdominal wall it answers above nearly to the middle belt. Clinical writers often restrict the term "lumbar region" to the "fossæ," one on each side of the lumbar vertebræ, and in this sense the right lumbar region and the left lumbar region can be defined.—The term *lumbo-sacral sulcus* is synonymous with the lumbar region as thus defined, and may be said to be that portion of the great spinal furrow or depression which extends along the entire region of the back on each side of the vertebral column and its associated muscles. The term triangle of Petit is often applied to a space defined laterally by the lateral border of the External Oblique muscle; medianly, by the lateral border of the Latissimus Dorsi muscle; and inferiorly by the crest of the ilium.

The lumbar region is concave in the erect position, and convex in forward flexion. The concavity is more pronounced in females than in males, and is excessive in coxalgia.

The spinous eminences of the lumbar vertebræ can be readily felt beneath the skin of the loins, and when the body is erect lie in a shallow linear depression.

The fourth lumbar spine answers to a line drawn across the loins at the level of the crest of the innominate bone.

The chief localities of the lumbar region relate to the positions of the ascending colon, the descending

¹ Annals of Anat. and Surg., ix., 1882, 189.

¹ R. Bright, Guy's Hosp. Rep. ii., 1837, 436 (fig.).

colon, and the kidneys. Both portions of the colon correspond in position to a vertical line which extends upward from the middle of the iliac crest. The descending colon lies a little nearer the median line than the ascending, and is often found lying in front of the lateral edge of the *Quadratus Lumborum*.¹

The position of the kidneys answers to the area of dull percussion in the lateral portion of the lumbar region, and which extends from the line of the twelfth rib to within nearly two inches of the crest of the ilium. The right kidney is, as a rule, from a half to three-quarters of an inch lower than the left.

Bartels² restricts the region of renal dulness to a space which measures two inches (five cm.) square in the "lumbar region." He states, quoting from Heller, that the lower margin of the kidney almost invariably lies within the pelvis.

According to Trousseau, the loins may be oedematous in peri-nephritic abscess.

THE UPPER EXTREMITY.³

The Superficial Anatomy of the upper extremity is treated of under the heads of the

- Region of the Shoulder.
- Region of the Arm.
- Region of the Elbow.
- Region of the Forearm.
- Region of the Wrist.
- Region of the Hand.

¹ In support of the statement made on p. 274, that the muscle may be incised with advantage in searching for the gut in the operation of colotomy, L. McLane Tiffany (Maryland Med. Journ., Aug. 4, 1883) found that in four operations he was compelled to divide the *Quadratus Lumborum* freely; twice because the gut came into view—the peritoneum intervening—and twice because the gut was felt to be posterior, *i. e.*, to the vertebral side of the edge of the muscle. Tillaux (*Traité d'Anat. Topog.*, fig. 210) figures the descending colon lying in front of the *Quadratus Lumborum*, and includes among the structures divided in the operation the *Quadratus Lumborum*. See also Braune, *Topographical Atlas*, pl. xvi. The author is desirous of making these statements, since some English writers direct the incisions for colotomy to be made on a line beyond the lateral border of the muscle.

² Ziemssen's *Encyclopædia*, xv. 9.

³ The fetal position of the superior extremity with the arm adducted, the elbow flexed, the fingers semi-flexed or extended, and the thumb uppermost, may be assumed to be the best for the study of the subdivisions of the limb.

As in the relation of nerves to muscles, so in relation of nerves to skin, it is found that the regions occupied by extensor muscles (namely, the lateral regions) are more prone to localization of constitutional phases of disease than are the flexor surfaces. Such, for example, is the localization of the trophic lesions of leprosy. In ichthyosis the flexor aspects are exempt. From the circumstance that in inflammatory invasions of trunks of mixed nerves the motor

The Shoulder. The region of the shoulder is treated by continental writers as embracing all the parts entering into the extrinsic muscles as they are inserted into the clavicle and the scapula, the region of the attachments found between the clavicle and the trunk, as well as those between the scapula and the humerus. In this book the English usage will be followed, and the front of the shoulder will be included in the anterior thoracic region; the back of the shoulder in the posterior thoracic region; and the region of the shoulder proper will be restricted to the rounded surface answering to the Deltoid muscle, and which constitutes the deltoid region of Hyrtl.

The shoulder covers the humero-scapular articulation, and answers to the upper half, nearly, of the lateral aspect of the humerus.

The region of the shoulder is very prominent in muscular individuals, but is flat or even concave in persons in whom dislocation of the head of the humerus exists, or paralysis of the Deltoid muscle has occurred.

The axilla and the lateral limit of the infra-clavicular fossa lie to the median side of the region; the swelling over the *Infra-Spinatus* muscle, to the lateral side; the swelling of the *Triceps* muscle, distally to it; and that of the *Trapezius* muscle, proximally.

The spine of the scapula and the acromial portion of the clavicle form parts of a continuous line which can be felt beneath the skin.

The deltoid bursa (subacromial bursa) is situated beneath the muscles at the upper margin of the region. It may be enlarged and be readily defined in the living subject. When of large size and when the

filaments in the nerves resist the effects of morbid action longer than do the sensory, analgesic tracts of the lateral skin surface are often detected in the course of such diseases as *Lepra nervorum* (A. Nesser, *Ziemssen's Handbuch. Haut-krankheiten*, 1883, i. 622.)

The arbitrary division of the superficies of the superior extremity is based upon the conceptions of common life or upon considerations which are purely surgical in their applications. The position of the larger joints has been the standard. For general clinical purposes, especially for the student of neurology and dermatology, it is better to divide the limb into regions which are based upon the distribution of the superficial nerves. Thus the region of the Deltoid muscle is defined by the integument receiving the cutaneous branch of the circumflex nerve; the region of the arm from the Deltoid to the orifices of escape of the internal and external cutaneous nerves, and it is supplied by the lesser internal cutaneous nerve; and the remaining portion of the limb is supplied by the internal cutaneous, the external cutaneous, and the superficial branches of the radial nerves. The points of anastomosis of the cutaneous nerves are of clinical interest.—The arm may be divided into median and lateral surfaces, rather than anterior and posterior.

muscle is relaxed, the bursa can be felt on the anterior aspect of the tendon of the Biceps muscle.¹

The *skin* over the region of the shoulder presents no features of interest. It is supplied by the cutaneous branches of the circumflex nerve and the supra-scapular nerves. According to Hyrtl² (since the parts are covered with fasciæ which are continuous with fibrous dissepiments and these in turn continuous with the periosteum of the humerus), the region of the shoulder is peculiarly liable to rheumatic attacks.

THE REGION OF THE ARM.

The Region of the Arm may be said to be bounded above by the region of the shoulder and below by the region of the elbow-joint. The form of the region is determined by the humerus at about the surgical neck to a line joining the epitrochlea and epicondyle, and by the bellies of the Biceps, Coraco-Brachialis, and Triceps muscles, and the origins of the Supinator Longus, Extensor Carpi, Radialis Longior, and Extensor Carpi Radialis Brevior. The arm is obscurely prismoidal in figure in an athletic male adult, but is cylindroid in young women and in children. The arm presents a lateral and a median surface. The first named is limited proximally by the deltoid impression, while the second named joins the axilla. The following includes the chief surface markings. A depression at the insertion of the Deltoid muscle is on a level with the insertion of the Coraco-Brachialis muscle and the origin of the Brachialis Anticus. It is at this point of the shaft of the humerus that the angulation (see p. 175) sometimes exists, and at a point on the median aspect that the foramen of the nutrient artery of the shaft is situated. A depression answering to the position of the external intermuscular septum disappears abruptly at the origin of the Supinator Longus. It was formerly a favorite locality for the introduction of the seton. At its base the conspicuous supra-condyloid ridge can be felt. A median groove, the more pronounced of the two, corresponds in position to the main arteries and nerves of the arm, and is lost below in the anterior elbow-fold.

The epicondyle and epitrochlea are conspicuous processes at the lower part of the arm. The ulnar nerve lies close behind the epitrochlea. Both bony processes form favorable localities for fixation of bands in making traction on the humerus. The nerve is remarkably enlarged in this situation in trophic forms of leprosy.

A cluster of two or three small lymphatic glands lies on the median aspect a short distance above the epitrochlea. These glands are often enlarged in secondary syphilis, and may become inflamed in angeio-leucitis.

The course of the brachial artery is best determined when the arm is moderately abducted and the forearm supinated. The artery then pursues an oblique course downward and outward. Above, it lies to the median side of the humerus; but below, it lies more to the front of the humerus.

The *skin* of the arm is very mobile, and permits the course of the larger veins to be outlined beneath it. It is thinner and more delicate upon the median than the lateral aspects. It is here that the effects of pressure, from ill-applied surgical apparatus, is the most distressing. In the operation of rhinoplasty, after the method of Taliacozzi, the skin is secured from this region.

The skin of the arm is supplied on its median aspect as follows: the upper two-thirds by the branches of termination of the lesser internal cutaneous nerve and nerve of Wrisberg; and the lower fourth by the internal cutaneous nerve. The three cutaneous nerves pierce the fascia from in front a short distance above the elbow. The lateral aspect is supplied by branches of the circumflex and musculospiral nerves.

Small unimportant bursæ have been defined at the epicondyle and the epitrochlea.

THE ELBOW.

When the Elbow-joint is completely flexed the proximal third of the front of the forearm lies in contact with the distal third of the front of the arm. A conspicuous anterior skin-fold is created by this position which, if continued posteriorly, would intersect the epitrochlea and epicondyle, and which, when seen while the joint is semi-flexed, receives the name of the anterior skin-fold (*pli du coude*, *plica cubitalis*). The region of the elbow may be said to be inclosed in lines circling the arm for two fingers' breadth above and below this fold.

The following are the principal points of reference of the elbow. Seen from in front there is detected a lateral swelling, due to the Supinator Longus and the underlying Extensors of the Carpus. On the median surface is seen the less conspicuous eminence of the flexor mass. Between them is a V-shaped groove leading upon the arm to the bicipital grooves, and in common with them determined by the Biceps muscle.

¹ C. B. Nancrede, *International Encycl. of Surg.*, ii. 709.

² *Topog. Anat.*, ii. 294.

According to Hyrtl,¹ a bursa may be felt on this surface between the tendon of the Biceps muscle and the tuberosity of the radius which may attain the size of a walnut and be sufficiently dense to be taken by the observer for an exostosis. In favorably selected subjects the coronoid process may be felt in front of the joint when extended. The joint is not, strictly speaking, parallel to the axis of either the arm or the forearm, but exhibits an angle at the inner aspect of the joint by the intersection of these two lines.

Seen from behind, the olecranon and the position of the superficial bursæ are indicated. Both the superficial and the deep bursa may become sufficiently enlarged to form a conspicuous swelling in the living subject.

The *skin* of the elbow is thin and delicate anteriorly but thick posteriorly, and is everywhere free from hair except along the posterior surface. The anterior surface except in very fat persons is marked by superficial veins, especially when the arm hangs at the side. The skin possesses considerable reparative power, as is seen in the recovery from wounds and incisions. On the outer side of the olecranon is a dimple-like depression which is most conspicuous when the elbow is extended, and which corresponds in position to the head of the radius. The depression is bounded laterally by the Anconeus, and medianly by the Supinator Longus and the Extensor Carpi Radii muscles.

THE FOREARM.

The Forearm presents the figure of a club, whose base is proximal and rounded, and whose short handle is distal and compressed from side to side. The forearm lies between the lower limit of the region of the elbow (two fingers' breadths below the anterior elbow-fold), and the first of the transverse lines which form the proximal limit of the wrist on the anterior surface of the limb. The forearm exhibits a few eminences which answer to separate muscles even when they are at rest. On the anterior surface above the wrist are seen the tendons of the Palmaris Longus and Flexor Carpi Radialis. On the same surface when the wrist is slightly flexed, the tendons of the Flexor Sublimis Digitorum and the Flexor Carpi Ulnaris can be identified. When the thumb is held up and the ulnar border of the hand is depressed, the tendons of the Extensor Carpi Ulnaris and the Flexor Carpi Ulnaris can be

felt distinctly above the wrist-joint. In forced extension of the thumb a slight fulness can be detected on the lateral surface of the forearm over the position of the origin of the Extensor Ossi Metacarpi Pollicis muscle. The remaining muscles of the forearm give bulk to the forearm and more especially form the rounded, firm, cushion-like masses, which embrace the bones at the proximal two-thirds. The chief muscular mass is placed in front rather than back of the radius and ulna.

The head of the ulna and the median margin of the shaft can be felt as well as the lower two-thirds of the shaft of the radius including the styloid process.

The *skin* is delicate and smooth in front, but thick behind. It is much less mobile than in the arm. The posterior surface is, in the male, covered with hair.

THE WRIST.

The region of the Wrist is defined by a space two fingers in breadth, above and below the line of the wrist-joint. It is in a general way limited by the linear depressions which answer to skin-folds on the anterior surface of the wrist.

The anterior or flexor surface is subdivided into two subregions, the radial and the ulnar. The *radial subregion*, the smaller of the two, lies between the tendon of the Extensor Ossi Metacarpi Pollicis and the Flexor Carpi Radialis. The pulsations of the radial artery can be felt in this region. The *ulnar subregion*, owing to the smaller bony surface underlying it, as compared to the radial, is cushion-like. It lies between the Flexor Carpi Radialis and the Flexor Carpi Ulnaris. Conspicuous in this region is the tendon of the Palmaris Longus.

The extensor or dorsal surface extends from the Extensor Ossi Metacarpi Pollicis to the tendon of the Flexor Carpi Ulnaris. It thus embraces both the radial and the ulnar borders of the region. The space between the Extensor Ossi Metacarpi Pollicis and the Extensor Secundi Internodii Pollicis (radial fossa, *tabatière anatomique*) is best seen when the muscles are contracted, and answers to the position of the scaphoid bone and the trapezium.—The ulnar border is most pronounced in supination.—When the wrist-joint is semiflexed the euneiform bone can be felt lying to the lateral aspect of the movable pisiform bone. Between the ulnar and radial borders, when the fingers are extended, the tendons of the Extensor Communis Digitorum can be felt; the Extensor Minimi Digiti can be detected when the little finger is extended;

¹ Topog. Anat., ii. 289.

and the Extensor Carpi Ulnaris when the hand is turned downward, while the thumb is held up.

A knife thrust inward beneath the styloid process of the ulna will enter the wrist-joint, but one thrust inward below the styloid process of the radius will strike the scaphoid bone.

The *skin* is thin, delicate, and smooth over the anterior aspect of the joint, but is hairy and thicker, and less mobile over the posterior.

THE HAND.

The Hand embraces that portion of the superior extremity which is placed distally to the wrist. The sides of the wrist expand abruptly to be continuous with those of the hand. The hand is divided into

The Body of the Hand.

The Fingers.

The Body of the Hand presents an anterior surface, a dorsal surface, and two borders, the radial and the ulnar.

The Anterior Surface (palmar surface, the palm), is quadrangular in form, and is slightly larger than the dorsal. On this surface can be felt, in addition to the muscles named below, the Adductor Pollicis, the Abductor Indicis, and the tendons of the Flexor Sublimis Digitorum. It is subdivided into the thenar and hypothenar eminences, the transverse pad, and the "hollow of the hand."

The *thenar eminence* (ball of the thumb) is the name given to that eminence which corresponds to the Abductor Pollicis, Opponens Pollicis, and Flexor Brevis Pollicis muscles.

At the proximal base of the thenar eminence can be felt the tubercle of the scaphoid bone and the ridge of the trapezium. The sesamoid bones of the thumb can also be distinguished in some subjects.

The *hypothenar eminence* is that eminence over the Abductor Minimi Digiti, the Flexor Brevis Minimi Digiti, and the Opponens Minimi Digiti muscles. To the inner side of the base the pisiform bone can be felt.—The thenar and hypothenar eminences sometimes receive the name of the *heel of the hand*. The skin uniting the two eminences overlies the deep annular ligament.

The *transverse pad* of the palm is a thick cushion of skin and subcutaneous fat which answers to the position of the head of the metacarpal bones, and the proximal portions of the phalanges of the first row. In front at the "interdigital spaces" the transverse pad enters into the composition of the web of the fingers.

The form of the *web of the fingers* is maintained by the superficial transverse ligament. The transverse pad is marked opposite the web by three small pulp-like elevations, which answer, during forced flexion of the fingers, to the interdigital spaces between the second and third phalanges. The pad becomes flattened in extension of the fingers, but is conspicuous, and serves to deepen the hollow of the hand, in flexion.

The *hollow of the hand* is that triangular depression whose apex is directed proximally, and which intervenes between the thenar eminence, the hypothenar eminence, and the transverse pad.

The Dorsal Surface of the body of the hand is bounded proximally by the wrist, and distally by the web of the fingers. On this surface can be felt the shafts and heads of the metacarpal bones, the positions of the Dorsal Interossei muscles, and the tendons of the Extensor Communis Digitorum muscle.

The *skin* of the body of the hand is thin over the thenar eminence, where it has supplied the flap in rhinoplastic operations, but thick elsewhere on the anterior aspect, while it is uniformly thin over the dorsal.—The skin of the palm is not subject to superficial abscess, as is that of the dorsum. Bursæ are not rare over the dorsal aspect of the metacarpopharyngeal articulations.

The skin-creases. The motions of the hand, which enter into the study of the skin-creases, are flexion and extension of the hand on the wrist and the fingers on the hand; and abduction and adduction of the thumb on the body of the hand.

The first crease lies at the junction of the thenar eminence and the hollow of the hand, and forms an oblique curved line, whose convexity is directed inward. It is determined by the motion of the metacarpal bone of the thumb toward the palm. The second crease is transverse, and answers in position to the metacarpophalangeal articulation of the index finger. It is pronounced at the radial border of the body of the hand, but becomes faint and disappears as it reaches the hypothenar eminence. The third crease is occasioned by the flexion of the third, fourth, and fifth metacarpophalangeal articulations. It is pronounced at the ulnar border of the body of the hand, and terminates at the position of the head of the second metacarpal bone.—The convexity of the superficial palmar arch lies, as a rule, in the space between the two transverse creases.—A number of secondary skin-creases mark the palm. Several of them lie in groups of small oblique lines, which are seen upon the ulnar side of the hypothenar eminence. One of these inter-

sects the transverse lines, and with them forms a fancied resemblance to the letter M. A second group lies in clusters upon the transverse pad, in the axial line of the metacarpal bones.

The Fingers. Each finger presents an anterior (palmar) surface, a posterior (dorsal) surface, and two lateral surfaces. The spaces between the fingers have received the name of the interdigital spaces. The space between the thumb and the index finger is spoken of as the "crotch of the thumb."

The fingers present a compact integument over the anterior, and a thin integument over the posterior surface. Transverse skin-folds mark the lines of flexion of the second and the third row of interphalangeal articulations, and, on the palm, between the proximal third of the first row of phalanges and the transverse pad of the palm. These folds lie on a line uniting the "web of the fingers."

THE INFERIOR EXTREMITY.

Unlike the shoulder, the hip embraces all the structures that are intermediate between the exert and trunkal portion of the limb; it is again unlike, in being rigidly fixed to the framework of the trunk.

An account of the superficial anatomy of the lower extremity will be described under the following titles:¹—

The Hip.	The Leg.
The Groin.	The Ankle.
The Thigh.	The Foot.
The Knee.	

THE HIP.

The Hip² (gluteal region, region of the buttock), is semicircular in form, and is defined above by the

¹ It is more difficult to arrange the surface of the lower extremity into natural regions than it is in the case of the superior extremity, for the reason that the entire limb is to a greater extent a natural region. The Gluteus Maximus and Tensor Vaginæ Femoris muscles, since they make tense the fascia of the thigh, and since the integument over them is supplied by the terminal branches of the posterior divisions of the lumbar nerves, may constitute a natural region (the posterior region of the hip of the text); the posterior surface of the thigh, which corresponds to the distribution of the branches of the small sciatic nerve, a second; the anterior surface of the thigh, which corresponds to the distribution of the terminal branches of the anterior division of the lumbar nerves (excepting the long saphenous nerve), a third; the posterior surface of the leg, and the lateral margin of the foot, a fourth; the median aspect of the leg, a fifth; the lateral aspect of the same, a sixth; and the dorsum of the foot, the region of the musculo-cutaneous nerves, a seventh; and the sole, an eighth.

² The region of the hip is restricted by Tillaux to the region about the hip-joint.

crest of the ilium; below by a horizontal line, which corresponds to the lower border of the tuberosity of the ischium; medianly (*i. e.*, toward the vertebral column) by the depression over the sacrum (sacral groove); and laterally, by an imaginary line, extending from the anterior superior spinous process of the ilium, to the great trochanter. This region is flat in the infant and in weak adults. It is convex in well-nourished subjects, and is especially full and rounded in females.

The upper third of the region is flatter, where it corresponds to the Gluteus Medius, than the lower two-thirds, where it corresponds to the Gluteus Maximus. The anterior border is on a line with the Tensor Vaginæ Femoris.

The *skin* of the posterior region of the hip is thick and brawny. It cannot be raised in folds with readiness, but the entire surface can be moved in a moderate degree, from side to side. It is a favorite locality for furuncles.

The skin at the line of the crest (iliac furrow) of the ilium is held well down to the bone, and forms in muscular individuals a well-defined depression. A marked depression overlies the trochanter major. A conspicuous fold (gluteal fold) corresponds to the lower margin of the Gluteus Maximus muscle when in a state of tonic contraction.—The gluteal fold is obliterated in the first stage of coxalgia, for the reason that the function of the Gluteus Maximus, in keeping tense the fascia lata, is suspended, and that the flexor muscles of the femur move the thigh slightly forward. The fold is a guide to the space beneath the Gluteus Maximus, and may be used as a point for the evacuation of blood and pus.—When the sciatic nerve is thickened, as in sciatica, it can be felt by deep palpation beneath the gluteal fold.

Four bursæ are enumerated in the region of the hip. The first is superficial, and lies between the skin and the tendon of the Gluteus Maximus muscle, as it glides over the trochanter major; a second is deep-seated, and lies between the tendon of the Gluteus Maximus and the trochanter major; a third is beneath the Gluteus Maximus and the tuberosity of the ischium; and a fourth, inconstant, is over the sacro-coccygeal articulation. All of these bursæ may become enlarged, and can be detected in the undissected subject. The first-named may become distended, and be in part occupied by barley-like nodules, or may suppurate; the second, may suppurate, and from its intimate association with the bone lead to caries; the third, may become moderately enlarged, and in the aged exhibit enormously thick-

ened walls, and be traversed by bands; and the fourth, has been described by Luschka and Hyrtl as susceptible of enlargement. The writer last named suggests that when this bursa is found enlarged in infants, it should be studied in connection with the appearances of spina bifida, of which, when imperfectly developed, it may be a related defect.

The points that can be distinguished by palpation in this region are the crest of the ilium, the anterior and posterior superior spinous processes (the last named being on a level with the second sacral spine), the prominence over the sacral spines and over the great trochanter, as well as a depression directly behind this eminence.

The space between the Gluteus Maximus and Gluteus Medius is sometimes the seat of blood extravasation and of abscess. *Fistulæ* may also point here. As a rule it may be said that the affections of this region are initiated elsewhere, either in the cavity of the pelvis (from which space they may involve the region of the hip through the sacro-sciatic foramina), or in the bones.

By Nélaton's line is meant an imaginary line extending from the anterior superior spinous process of the ilium to the centre of the tuberosity of the ilium.

THE GROIN.

The Groin¹ (inguinal region, *trigonum inguinale*, upper femoral region) is that space which is defined upon the anterior surface of the thigh by Poupart's ligament above, by the continuation of a line which unites the lower limit of the femoro-scrotal with the gluteal fold below; and, to the outer side, by an imaginary line which extends between the anterior superior spinous process of the ilium and the great trochanter.

The groin is thus a triangular space which answers to the lines of voluntary flexion of the thigh on the abdomen. The lower limit corresponds to a line uniting the points of exit of the middle cutaneous and the small sciatic nerves.

The *skin* of the groin is thin and delicate and at the median third is covered in the adult with hair; toward the pubis the skin is furnished with numbers of sweat and sebaceous glands, is liable to attacks of intertrigo, and may be involved in eczema of the genitals and the perineum. As a rule, the skin is translucent, and permits the course of the superficial veins to be dis-

cerned beneath. In cicatricial contractions, the skin may aid in maintaining states of morbid flexion of the thigh on the abdomen. While mobile and distensible, and readily accommodating hernial and fatty tumors, the skin may be torn on sudden forced extension of the thigh from a position of previous flexion.—It may resemble that of the abdomen in women who have borne children.—Skin-incisions gape more when transverse than when vertical; hence it has been recommended by Malgaigne to open abscesses by vertical incisions.

The following structures can be detected by touch in the groin. Poupart's ligament can be felt at the bottom of the depression which extends from the anterior superior spinous process of the ilium to the spine of the pubis. The outer half of the ligament is the more distinct. The ligament is relaxed in flexion of the thigh on the abdomen, and on flexion and adduction of the thigh.—The inguinal lymphatic glands can be detected, especially in thin young subjects.—The bursa beneath the conjoined tendon of the Iliacus Internus and Psoas Magnus muscles is sometimes sufficiently distended to be felt. When thus abnormally enlarged, it may be mistaken for psoas abscess.—The pulsations of the femoral artery can be felt. Pus from a psoas abscess and hernia through the obturator foramen readily involve the inguinal region.

THE THIGH.

The Thigh includes that region which lies between a line encircling the limb at the gluteal fold, and a second line, at the upper margin of the *cul-de-sac* of the knee-joint, when the thigh is extended. The line last named encircles the limb one-and-a-half inch above the patella.

The thigh is cylindroid in form in well-nourished females and infants, but it is less regular in form, and is marked by numbers of eminences in muscular adults, in whom the thigh is rounded on the lateral and posterior surfaces, is slightly convex on the anterior, and is flat upon the median surface. The form of the thigh is due to the shaft of the femur at a portion which answers to the *linea aspera* and to the deep fascia which incloses the muscular masses.

The *skin* is thicker upon the lateral than upon the median aspect. It is everywhere freely movable, but is especially mobile over the outer hamstrings and along the lower median surface. In well-nourished infants the skin is marked by several transverse folds, which may become the seats of intertrigo.—Varicose veins are not unfrequently seen beneath

¹ The groin is, in common language, the depression between the abdomen and the thigh, while the inguinal region pertains to the iliac region of the abdomen as the term "inguinal canal" would indicate. While the two terms are thus not, strictly speaking, synonymous, they are interchangeably used in clinical reports.

the skin of the anterior surface.—The skin of the lateral surface is often perforated by fistulous tracts in necrosis of the shaft of the bone.

The following points can be detected in the thigh: A band of fascia lata can be felt extending below the Tensor Vaginæ Femoris; this band is most pronounced in emaciated males, and forms near the trochanter, and near the knee-joint, a conspicuous line beneath the skin. The eminences of the Vasti muscles, the Rectus Femoris, and (when the leg is flexed and adducted) the belly of the Sartorius muscle, on the front of the thigh; the adductor mass, especially the Adductor Longus, on the median surface; the tendon of the Biceps Femoris on the lateral border; and the tendons of the Semimembranosus and Semitendinosus on the median border of the posterior surface.—A well-defined depression ordinarily exists on the upper aspect of the thigh between the Rectus Femoris and the Adductor mass.

THE KNEE.

The region of the Knee is defined proximally by a line encircling the limb at the upper border of the *cul-de-sac* one-and-a-half inch or two fingers' breadth (rarely two inches) above the patella, and distally by a line encircling the limb immediately below the tubercle of the tibia.

The region of the knee is smaller than that of the thigh or the leg, and exhibits but little disposition to the accumulation of fat. It is relatively larger in children than in adults, and in rachitic than in normal subjects.

The region of the knee is divided into two regions: the anterior, and the posterior.

The Anterior Region is subpyramidal in form; the sides of the figure are composed of the lateral and median surfaces of the joint and their overlying structures, where the summit is represented by the patella. It receives more accessions from the fascia lata than does the posterior region.

The *anterior surface* (front of the knee). The patella forms the most conspicuous feature of the anterior surface. This bone is freely movable from side to side in extension, but is fixed against the femur in flexion. The median border is better outlined than the lateral. The edges of the inter-condyloid notch can be determined. Below the patella the position of the ligamentum patellæ can be ascertained. A shallow depression is seen on each side of the ligament in slender subjects, but, in the well-nourished, there is seen at this

point a convex surface due to the presence of a quantity of underlying fat. In chronic diseased conditions the serous exudation into the fat of this region causes the masses to become exceptionally prominent, and to constitute an important feature in the superficial appearance of the joint. Care should be taken not to confound the soft, yielding character of these swellings with abscess.

The bursæ, which may be determined by palpation, are two in number. The first and most important lies directly in front (covering the lower two-thirds) of the patella. When enlarged it constitutes "house-maid's" knee, and may be the size of an egg or small orange. It may suppurate and even lead to caries of the patella. The second bursa lies beneath the ligamentum patellæ, as this structure is attached to the tibia. It is less frequently enlarged than is the prepatellar bursa. Hyrtl describes a bursa (pretibial bursa) lying in front of the tubercle of the tibia and of the ligamentum patellæ. It is acquired, and thus differs from the two foregoing.

The extension of the synovial membrane, above the patella, determines a point at which the synovial chamber can be punctured. It is recommended to insert the instrument a little above and to the median side of the patella.

The *skin* of the anterior region is thicker and rougher over the patella than at the sides of the joint, and in extension in many subjects is thrown into a number of minute transverse folds.

The *lateral surface* (external surface, outer side of knee) is flat or slightly concave. The external condyle of the femur, the tuberosity of the tibia, the interarticular depression between the femur and the tibia, and the edge of the interarticular disk can be distinguished. A fold of fascia lata, which corresponds to the line of traction of the Tensor Vaginæ Femoris, is pronounced in extension. The external lateral ligament can be distinguished.

The *median surface* (internal surface, inner side of knee) presents more conspicuous bony prominences, but less pronounced fibrous structures, than does the external surface, but on the whole it is less sharply defined. Thus the general surface is convex from the projections of the internal condyle of the femur and the internal tuberosity of the tibia, while the interarticular depression is imperfectly defined, and the ligaments and bands of fascia lata are absent. The Adductor Magnus tubercle for the tendon of insertion of the muscle of the same name, can be felt a short distance above the internal condyle, where it corresponds

to the line of epiphyseal junction. The lower part of the Vastus Internus muscle can be determined.

The Posterior Region¹ (ham, back of knee) is hollow in flexion, but is flat or even convex in extension. The boundaries of the posterior region are best seen when the knee is semiflexed. They are then well defined by the tense folds which answer to the tendons of the hamstring muscles. The lower half of the popliteal space is less distinctly outlined, and answers to the soft yielding mass lying between the prominence of the head of the tibia and the head of the fibula.

The depression between the hamstrings is the *hollow of the knee* (popliteal fossa, sulcus poplitei).

The tendon of the Biceps can be easily distinguished at the outer border, and, in semiflexion, the external popliteal nerve also lying to its median side. In the same position of the joint the internal popliteal nerve can be felt in the median line at the centre of the ham. In yet deeper palpation the popliteal artery can be often felt pulsating. Along the median border the tendons of the Semitendinosus, the Semimembranosus, and the Gracilis can be easily determined.

Small superficial lymphatic glands can be distinguished beneath the skin in young strumous subjects. Owing to the dense fascia covering the joint posteriorly, the parts beneath the fascia can be imperfectly if at all defined. The deep lymphatic glands when enlarged form diffuse swellings of the ham. Collections of pus here tend to pass up or down the limb, or even into the joint rather than toward the surface.

The *skin* of the posterior region is delicate, and marked by a transverse crease at a point a little above the interarticular line. It may be greatly distended to accommodate a tumor or an aneurismal sac. On the other hand, it may contract in long-continued flexion of the joint, and has been known to rupture as a result of sudden and forced extension. The fat of the posterior region is more abundant than in the anterior, and may become the seat of abscess.

The bursæ of the posterior region are found on both the median and lateral borders, but are smaller and less constant along the lateral. An enlarged bursal swelling occurring between the tendon of the Biceps, and the external popliteal nerve, may be identified with the bursa normally present between the tendon of this muscle and the external lateral ligament. The bursæ that can be detected along the median border are commonly confined to the space between the inner head of the Gastrocnemius and the

tendon of the Semimembranosus. They may communicate with the joint. In the middle of the posterior region, the hernial protrusions of the synovial membrane may occur of sufficient size to be determined by manipulation. For the most part they can be distinguished from enlarged bursæ, not only from their position, but from the fact that in semiflexion gentle pressure will cause the tumors to disappear.

THE LEG.

The region of the Leg is defined proximally by a circular line which embraces the limb at the level of the tubercle of the tibia, and distally, by a second which encircles the limb directly above the malleoli.

The general form of the leg is conical, the base being upward. It is smooth and uniformly round in children and in women, but is irregularly prismoidal in men.

The leg is roughly divided into a muscular proximal two-thirds, and a distal tendinous one third. This division, while not exact, will serve to separate the bulky parts of most of the muscles of the leg from their tendons, as they lie within this region. The line of such a division nearly corresponds to the point of escape of the musculo-cutaneous nerve from the deep fascia.

The *skin* throughout is more adherent to the fascia than is the case in the thigh, and is in addition contrasted with that portion of the integument in being in close relation to both the tibia and the fibula for considerable portions of their length. Beneath the skin a sparse layer of fat is deposited anteriorly, but becomes thicker posteriorly.

Accepting the prismoidal form as typical, the leg exhibits three surfaces: an anterior, a lateral, and a posterior surface.

The *anterior surface* (antero-median region, region of the "shin") corresponds to the anterior surface of the tibia, and to the course of the anterior tibial vessel and nerve. At the upper portion, just below the tubercle of the tibia, the elongated swelling of the belly of the Tibialis Anticus can be felt, and to its outer side the belly of the Extensor Longus Digitorum. At the lower portion, immediately above the internal malleolus, especially when the ankle is flexed and the toes extended, the tendons of these muscles, together with the tendon of the Extensor Proprius Pollicis, can be felt as they lie along the tibia. The intermediate portion of the anterior surface is marked by the crest of the tibia, which can be thus felt, for nearly the entire length of the leg, as a sigmoid curve. To the outer side the corresponding anterior surface—

¹ For boundaries of the popliteal space, see p. 406.

the "shin," of common language—can be defined. In rachitic subjects this surface is uniformly convex.—The *skin* is firmly adherent to the underlying parts.

The *lateral surface* (peroneal region, antero-lateral region) is defined by the fibula, and answers to the location of the Peroneal muscles, peroneal vessels, and the external popliteal nerve. The position of the bone can be obscurely felt throughout. Above, the head can be readily distinguished, and below, namely, at its lower half, where the bone lies beneath the integument, the anterior surface can be easily outlined. The muscular mass about the upper half of the fibula corresponds to the Peroneus Longus and the Peroneus Brevis muscles.—The skin over the lateral region is more hairy than elsewhere on the leg.

The *posterior surface* is convex and broad. It is less pronounced in the negro than in the white race, and answers for the most part to the bulk of the Gastrocnemius and Soleus muscles. The inner longer head of the muscle first named can be easily distinguished. Toward the ankle the tendo Achillis forms a conspicuous feature. To the inner side of the tendon the posterior tibial artery can be felt pulsating, and the position of the tendons of the Tibialis Posticus and Flexor Longus Digitorum can be determined.—The *skin* of the posterior region is thinner, softer, and more yielding than upon the anterior or the lateral surfaces. The course of the short saphenous vein can often be noted.

THE ANKLE.

The Region of the Ankle is defined above by a line uniting the bases of the malleoli, and below by a line drawn round the limb at a point about half an inch below the malleoli; behind at a point on a level with the attachment of the tendo Achillis, and in front, about an inch in front of the lower extremity of the tibia. The region thus corresponds to that of the union of the tibia, fibula, and astragalus with one another, and embraces in addition the region of the head of the astragalus.

The ankle is remarkable for the absence of muscle tissue about it. It is of great strength behind and at the sides, but is weak in front.

The ankle is divided into an anterior, a posterior, a lateral, and a median surface.

The *anterior surface* (front of ankle) is marked from within outward, in the order in which they are here mentioned, by the tendons of the Tibialis Anticus, Extensor Proprius Pollicis, the Extensor Communis Digitorum, and the Peroneus Tertius muscles. These tendons are readily distinguished; that of the Tibialis

Anticus is the most conspicuous, and that of the Extensor Communis Digitorum answers to the middle line of the surface.—When the foot is fully extended, the convex surface of the anterior capsule of the joint can be felt lying between the internal malleolus and the tendon of the Tibialis Anticus.

The *skin* is smooth and delicate. It is thrown into a number of transverse creases in flexion.

The *posterior surface* (back of ankle) is marked by the prominent tendo Achillis. The upper portion of the tendon answers to the inter-articular line, on either side of which structure a hollow space is defined. The posterior tibial artery can be felt pulsating in the centre of the median hollow. The tendon of the Tibialis Posticus can be distinguished behind the internal malleolus in adduction of the foot. In synergic contractions of the Extensor Proprius Pollicis and the Flexor Longus Pollicis, a swelling appears in the median hollow which can be referred to the muscle last named. In flexion the outline of the deltoid ligament can be determined. In the lateral hollow can be felt (best in abduction and pronation of the foot) the tendons of the Peroneus Longus and Peroneus Brevis muscles.

The *skin* of the posterior surface is a little thicker than in front, and is freely movable over the tendo Achillis. Fat is abundant in the hollows at the sides of the tendon, but is nearly absent over the tendon itself. The bursa between the tendon and the calcaneum is sometimes distinguishable.

The *lateral and median surfaces* (sides of ankle) answer to the spaces over the malleoli, and present few points of interest beyond the outlines of the malleoli themselves, which are bold and distinct. The internal malleolus, while broader than the external, is less prolonged inferiorly, and is set a little more forward. The internal malleolus is obliquely placed to the axis of the tibia, while the axis of the external malleolus is in the same line as the longitudinal axis of the fibula.

THE FOOT.

The foot is that portion of the inferior extremity which is placed distally to the ankle-joint. But since the region of the ankle-joint is already defined, it is convenient to restrict to the foot that region placed in advance of a line drawn round the limb half an inch below the malleoli. The foot, as a whole, joins the leg at nearly a right angle.

The Region of the Foot is divided into—

The Tarso-Metatarsal Region.

The Region of the Toes.

The Tarso-Metatarsal Region (posterior region) presents a dorsal and a plantar surface.

The *dorsal surface* is smaller than the plantar, and is arched to correspond to the general form of the bones of the tarsus and of the metatarsus.

The belly of the Extensor Brevis Digitorum forms a soft, cushion-like mass on the lateral aspect of the dorsal surface, and exhibits, owing to the unyielding bony surface beneath it, a sensation resembling that of fluctuation, which has misled incautious practitioners to believe that a collection of fluid existed beneath the skin.

The *skin* of the dorsal surface is delicate, and is imperfectly adapted to bear the pressure of surgical appliances.

The general shape of the neck of the astragalus can be outlined when the foot is fully extended.

The *plantar surface* (sole), excepting along the lateral border, where it is flat, presents the form of a low arch (hollow of the foot), whose posterior buttress is represented in the heel, and whose anterior buttress constitutes the "ball of the toes."

The *skin* of the plantar surface is of great thickness, having an average of three lines, though it is much thicker and of callous consistence under the heel. It is also thicker than the average, but more elastic than elsewhere over the "ball of the toes." The structure last named extends across the sole in a position analogous to that occupied by the transverse pad in the hand. The "ball of the toes," as the name expresses, supports the toes at their basal portions as well as the body of the foot, and corresponds nearly to the proximal three-fourths of the first row of phalanges.

The skin of the arched portion of the sole is relatively thin, and possesses tactile sensibility in a high degree. The lips of an incision made in the skin of the plantar surface gap to a less degree than those made upon any other portion of the integument of the body.

The median border of the plantar surface merges insensibly into that of the ankle and of the dorsal surface. It presents from behind forward the following points: The tuberosity of the calcaneum, the sustentaculum tali, the head of the astragalus, the calcaneo-scaphoid ligament, and the tendon of the Tibialis Posticus muscles which, according to Chopart, in old subjects may present near its insertion a fibrous nodosity which may be mistaken for the tubercle of the scaphoid bone lying directly in front. The tuber-

cle last named is found one-and-a-half inch in front of the internal malleolus. Next in order are felt the first cuneiform bone, the sesamoid bones of the Flexor Brevis Pollicis muscle, the base of the first metatarsal bone, and finally, the head of the bone last named.

The lateral border from before backward exhibits the perineal tubercle (in exceptional instances this may be large and hook-like) between the Perineus Longus and Perineus Brevis tendon, the tendons of the muscles last named themselves, the anterior end of the calcaneum best felt when the foot is everted, and the conspicuous base of the fifth metatarsal bone. The cuboido-calcaneal joint lies eight lines back of this process.

The soft cushion-like mass which adjoins the median border is due to the Abductor Pollicis and Flexor Brevis Pollicis muscles.

The analogous mass lying along the outer border is due to the Abductor Minimi Digiti and the Flexor Brevis Minimi Digiti muscles.

The general outline of the plantar fascia can in part be determined as it lies between these two masses.

The body of the foot is the seat of a number of acquired bursæ, the positions of which are determined by valgus, varus, and by certain occupations.

The Region of the Toes (anterior region) presents a plantar and a dorsal surface. The plantar surface of each is concave from before backward, but convex from side to side, and is marked by transverse creases which correspond in position to the interphalangeal joints. Each terminal phalanx is convex and club-shaped.—The apposed surfaces of the toes are flat and join the dorsal surface by angulated borders.—The dorsal surface of the toes exhibits a delicate skin, which resembles that of the dorsum of the tarso-metatarsal region.

The first or great toe is in a line with the median border of the tarso-metatarsal region. It is commonly deflected outward in adults at the tarso-phalangeal joint, owing to the long-continued pressure of ill-fitting shoes, though such deviation may be the result of interstitial arthritic change. The median surface of the articulation is often the seat of an inflamed bursa having callous walls (bunion).

The second toe is a little longer than the first. It is often treated conventionally by sculptors as somewhat shorter than the first. The fifth or little toe has a marked motion in abduction. It is commonly deformed by pressure of the shoe.

EMBRYOLOGY AND THE STUDY OF MALFORMATIONS.

EMBRYOLOGY treats of the development of the embryo.

Since the chief interest which the physician finds in this science is the detection of relationships which exist between normal and abnormal processes, it is proposed in this chapter to give a brief outline of those phases of embryology which may be held to be useful in studying congenital defects. The object of such a study is to determine how far the laws of morphology can explain the aberrant structures of the human body, and to distinguish between such structures and the results of diseased action.

The study of congenital defects is included under Teratology. Literally interpreted, teratology is that science which treats of *monsters*; and, as originally proposed by Etienne Geoffroy St. Hilaire,¹ it treats of subjects in which are exhibited more than a single gross malformation. According to the same authority, specimens showing but a single defect are not to be considered as monsters, but as examples of *anomaly*.

This distinction never came into general use, and the terms *monster* and *anomaly* are now almost interchangeably employed. Neither the one nor the other term is accurate; for the term monster is simply a survival of a superstitious idea respecting the origin of a subject which may chance to exhibit gross defects; while no defect whatsoever can be considered an anomaly, since all so-called "anomalies" can be explained (if explicable at all) by the operation of those laws the effects of which are seen in the normal development of the organism.

The term *variation* expresses the unusual disposition of the parts of an organ or system of related structures. Variations have been more carefully studied in the osseous, muscular, circulatory, and nervous systems than elsewhere in the body. Unlike the subjects of "teratology" and "anomaly," "variations" may be both congenital and acquired.

The range of congenital variation in a given organ, and the relative rate of variations in different portions of the body are important subjects for investigation. In a general way it may be said that the

most plastic structures are either those which have retained to the greatest extent the formative peculiarities of the embryo (as, for example, the ovary), or those which have been added last in the processes of differentiation, as the occipital lobe of the cerebrum, the spleen, the thyroid body, etc.

The study of variation of an anatomical object, broadly considered, not only embraces the departures from a standard description, which is simply the average drawn from numbers of observations, but includes all structural phases of the life-history of the object under consideration. By it are implied, in addition, its modifications peculiar to sex, as well as its manner of responding to the impress of diseased action.

Among the acquired variations may be mentioned the shapes of the skull as dependent upon rates of brain-growth; the deviation of the nasal septum; the increase of planal cleavage in the muscles of athletes; the changes in the form of a bone by muscle-traction; the shape of the jaws in those persons who habitually breathe through the mouth; the deformation of the thorax dependent upon changes in rates of respiration; and the elevation of the aortic arch by increase of the action of the heart.

For the most part all accounts of variations in this book are appended to the descriptions of the organs in which they occur.

The Causes of Malformation.—In the early history of the embryo, malformation may be caused by violent agitation of the germ, by abrupt changes in its temperature, by the effects of inflammatory processes (*infra*), and by injury. The direct and immediate effects of any of these causes are often distinct from the indirect and subsequent effects. Thus a band of inflammatory adhesion between the amnion and the integument may distort superficial structures which appear thereafter in the entire region in which the adhesion occurs. In like manner intra-uterine fracture of the femur may distort the tibia and the fibula, invert or extend the foot, and reduce the number of the phalanges. Many of these effects are probably reflex phenomena, or those pertaining to the trophic influence of nerves.

Inflammatory effects are of two kinds: First, the effect upon the nutrition of a part by a thrombus, which has

¹ The numerous memoirs of this author (in the *Comptes Rendus* and *Mus. d'Histoire Naturelle*) extend over a period of twenty years, 1821-1840; see, also, *Philosophie Anatomique*, Paris, 1822.

been detached from a remote area of inflammation, and which thus obstructs an artery in a given region, impairs the rate of its development and growth; in this manner an endocarditis of the right side of the heart may be associated with absence of the right kidney, as a result of obstruction with a thrombus of the corresponding renal artery.—Second, the bands of union already mentioned between the amnion and the integument. These appear to be more common about the face than elsewhere. Förster¹ has figured symmetrical bands, which were attached to both eyes, and a single band² which extended from the mouth upward along the left side of the face. Similar methods of attachment may be associated with imperfect development of the face.³

The class of malformations in which parts are duplicated or are present in excess may also in part be explained by trophic action of nerves, since it is understood that in rapidly growing tissues a disturbance in the normal relation existing between a given structure and the nerves supplying it will terminate not in atrophic but in hypertrophic conditions.

Many examples, however, as in symmetrical duplication either of a part of the embryo or of the entire foetus, cannot be so explained. As aids to the study of such conditions, the laws of morphology, as these are defined in the structures of animals and plants, are of importance.

The mental attitude of the mother toward her offspring is often dwelt upon as a powerful factor in creating malformation; but while it cannot be discarded, it rests upon a less satisfactory basis than any of the general causes already outlined.—In a general way it can be said that all gross defects are examples of the manifold effects of malnutrition. Animals artificially raised or domesticated are more liable to have defective offspring than are those which can determine for themselves their surroundings; and human defects are more common among impoverished than among well-nourished individuals.

The correlations of deformities one to another indicate the harmonies present between the several parts of an organism. It has been found, for example, that cleft-palate and single kidney are often associated. Defects of the hairs are apt to be associated with defects of the teeth and of the nails. Congenital defects of the oesophagus and the respiratory apparatus, and of the deeper veins and the degrees of lobulation of the lungs, are often related. Parts arranged in serial order as the vertebræ, the several parts along an embryonic rod as a visceral

arch, are commonly multiple. A nerve-centre, such as a motor-centre of the cerebrum, will modify the area controlled by that centre. In like manner, absence of the olfactory nerve and its cerebral tract will violently disturb the formative processes of the region to which the peripheral filaments are normally distributed.

The brain exerts a profound influence over the etiology of malformation. A tendency to cerebral precocity is found by D. Hunt to be associated with myopia. It is probable that the absence of myopia in the negro as determined by S. D. Risley is a correlation with the low rates of cerebral development in this race. It is also probable that true asymmetry of the nasal chamber has a similar causation.

According to Lawson Tait,¹ geographical situation has much to do with the relative frequency of cleft palate. He instances the curious fact that all lion whelps born in the London Zoological Garden have cleft palate, while in other gardens this deformity is unknown. In some districts of Yorkshire, cleft palate would seem to be endemic, and is not merely a family peculiarity.

One of the most important correlations in embryology is that existing between the internal and external conditions of many parts of the body. The elements of the derm and epiderm appear to be under the trophic control of the deeper organs which they are intended to protect. Defects of the bladder correlate with defects of the skin over the region of the bladder; spina bifida, with the skin over the affected part of the vertebral column; a defect of the olfactory lobes or tracts, with the skin of the external nose, etc. In defects of the ovaries and testes, the external organs of generation are always in sympathetic relation.

It is an open question to what extent a malformed foetus can be designated a genus, or to what degree the subdivision of each genus may receive the name species. So long as naturalists are not agreed as to the restriction of these terms in normal plants and animals, no exact premises can be presented by which the subject can be rationally discussed. A classification of monsters based upon the laws of development and the causes exciting aberration would, all things remaining equal, be the most satisfactory; but, in the absence of the data warranting such an attempt, it has been thought best to employ the nomenclature which has been sanctioned by custom. Isidore Geoffroy St. Hilaire² has proposed a classification of gross congenital defects based upon the prin-

¹ *Misbildungen*, Pl. xxv. fig. 31.

² *Ibid.*, Pl. xviii. fig. 31.

³ *Ibid.*, Pl. xv. fig. 22.

¹ Steiner's *Compendium of Children's Diseases*, Am. ed., 201.

² *Histoire Gén. et Partic. des Anomalies*, etc. Paris, 1832–36.

ciples of the bi-nominal nomenclature of Linnæus. This classification is yet in use among French writers. As modified by A. Förster,¹ it may be said to serve the purpose of later systematists. For convenience in reference the system of Förster is herewith appended.

A CLASSIFICATION OF MALFORMATIONS ACCORDING TO
FÖRSTER.

I. Monsters per excessum.

1. Monsters with supernumerary formations.

A. Double Monsters.

a. Terata katadidyma.

Diprosopus (Fig. 197).

Dicephalus. { D. dibrachius (Fig. 198).
D. tribrachius.
D. tribrachius tripus (Fig. 199).
D. tetrabrachius (Fig. 200).
D. tetrabrachius tripus.

Ischopagus. I. tetrapus (Fig. 201).

Pygopagus (Fig. 202).

b. Terata. T. anadidyma.

Dipygus. { D. tripus (Fig. 203).
D. tetrabrachium (Deradelphie, St. H.).

Syncephalus. (Cephalothoracopagus, Iniope² St. H. Janiceps), (Fig. 204).

Craniopagus (Fig. 205).

c. Terata anakatadidyma.

Prosopthoracopagus (Hemipage, St. H., Epignathus Prosopopagus) (Fig. 206).

Thoracopagus { T. tribrachius (Fig. 207).
(Sternopagus, T. xiphopagus.
Synthorax). T. tripus.
T. parasiticus (Fig. 208).

Rhachipagus.

B. Three-faced Monsters. (Tricephalus.)

C. Supernumerary.

Formation of single limbs and organs.

of all or part of limbs.

of fingers and toes.

of some bones and muscles.

of viscera.

2. Monsters with excessive formation.

Excessive size of entire body.

Precocious developments.

Excessive size of limbs and certain organs.

II. Monsters by defects.

1. Incomplete formation of the entire or part of body.

A. Acardiaci.

Amorphus (Anideus, Mylacephalus, St. H.) (Fig. 209¹).

Acornus (Fig. 210²).

Acephalus (Fig. 211).

B. Dwarfs (Nanosomia, Microsomia).

2. Incomplete formation of special parts of the body.

A. Incomplete formation of limbs.

a. Of all extremities. { Amelus (Fig. 212).
Peromelus (Fig. 213).
Phocomelus (Fig. 214).
Micromelus.

b. Of superior extremities. { Abrachius.
Perobrachius.
Microbrachius.
Monobrachius.

c. Of inferior extremities. { Sympus (Sympodia Siren-monster).
S. apus (Sirénomèle. I. St. H.) (Fig. 215).
S. monopus (Uromèle. I. St. H.) (Fig. 216).
S. dipus (Symèle. I. St. H.) (Fig. 217).

Apus (Fig. 218).

Monopus (Fig. 219).

Peropus (Micropus).

Achirus (Perochirus) (Figs. 220, 221).

d. Of hand and feet. { A. dactylus (Perodactylus, Microdactylus).
Syndactylus (Fig. 222).

Lunatio congenita.

e. Lower limb and foot. { L. fem. congen. (Dysarthrosis ilio-femoris).
L. genu congen.
L. pedes congen.
Pes varus.
Pes valgus.
Pes equin.
Talipes.

f. Upper limb and hand. { L. humeri congenita.
L. radii congenita.
L. manus congenita.

¹ The description of this fig., p. 753, is as follows:—

a, b, umbilical artery and vein; c, sac filled with a whey-like fluid; d, e, solid processes; f, skin mass; g, a fold of amnion; h, a cul-de-sac resembling mesentery.

² The description of this figure, p. 753, is as follows:—

a, spongy mass in the position of the brain; b, the left palpebral fissure; c, the right palpebral fissure; d, the nose; e, the mouth; f, the right ear; g, h, occipital sac; i, an undetermined mass; k, the umbilical cord.

Fig. 197.



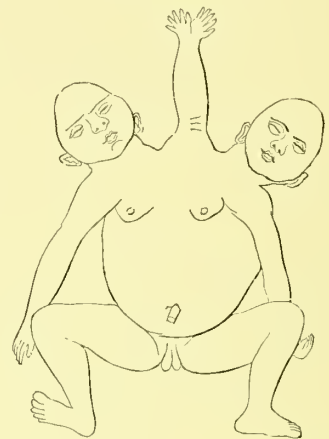
Diprosopus triophthalmus.

Fig. 198.



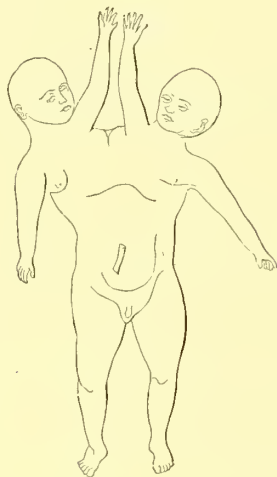
Dicephalus dibrachius.

Fig. 199.



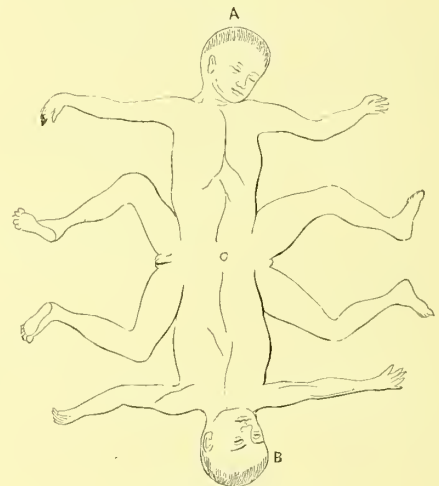
Dicephalus tribrachius.

Fig. 200.



Dicephalus tetrabrachius.

Fig. 201.



Ischiopagus tetrapus.

Fig. 202.



Pygopagus.

Fig. 203.



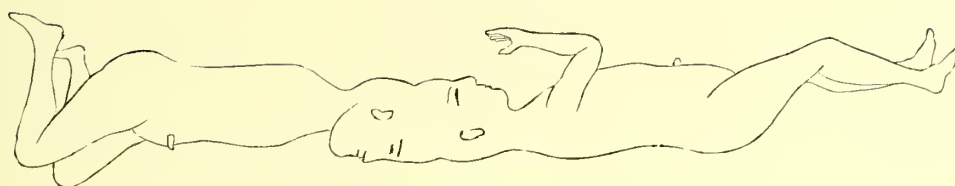
Dipygus tripus.

Fig. 204.



Syucephalus.

Fig. 205.



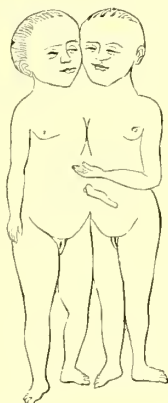
Kraniopagus parasiticus.

Fig. 206.



Prosopothoracopagus.

Fig. 207.



Thoracopagus tribrachius.

Fig. 208.



Thoracopagus parasiticus.

Fig. 209.



Amorphus.

Fig. 210.



Acormus.

Fig. 211.



Acephalus.

Fig. 212.



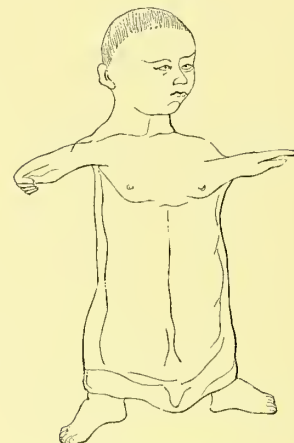
Amelus.

Fig. 213.



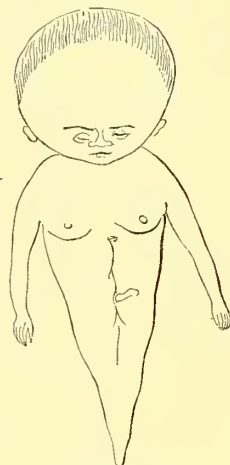
Peromelus.

Fig. 214.



Phocomelus.

Fig. 215.



Sympus apus.

Fig. 216.



Sympus monopus.

Fig. 217.



Sympus dipus.

Fig. 218.



Apus.

Fig. 219.



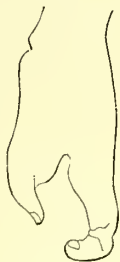
Monopus.

Fig. 220.



Perochirus.

Fig. 221.



Perochirus.

Fig. 222.



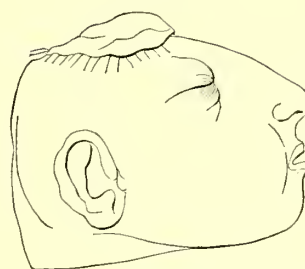
Syndactylus.

Fig. 223.



Anencephalus.

Fig. 224.



Hemicrania.

Fig. 225.



Hydrencephalocoele anterior.

Fig. 226.



Hydrorrhachis cervicalis.

Fig. 227.



Agnathus.

B. Incomplete formation of skull and vertebral column.

- Cyclopia (Monopsia, Monophthalmia).
- Hydrops canalis medullaris.
- Anencephalus (Amyelia) (Fig. 223).
- Hemicrania (Fig. 224).
- Cranioschisis (Rhachischisis).
- Hydrencephalocoele (Hydromecele) (Fig. 225).
- Hydrorhachis (Hydrocephalus) (Fig. 226).
- Micrencephalis (Cretinisin).
- Partial defects of brain and of the spinal cord.

C. Incomplete formation of the face.

- { Agnathus (Fig. 227).
- { Schistoprosopus (Aprosopus).
- { Cheiloschisis. Gnathoschisis. Palatoschisis.
- { Synchelia.
- { Microstomia.
- { Micrognathia (Atelognathia).
- { Achelia (Microchelia, Bachychelia).
- Aglosia.
- Microglossia.
- Schistoglossia.

D. Incomplete formation of the neck.

- Fistula colli congenita.

E. Defects and atresia of the chest.

- { Defects of the thorax.
- { — of the mamma.
- { — of the lung and the heart.
- Defects and atresia of the œsophagus, the larynx, the trachea.

F. Incomplete formation of the abdomen.

- { Arrest of development of the abdominal wall, etc.
- { Incomplete development of the abdominal wall.
- Umbilical hernia.
- Inversion of bladder, ectrophy of bladder.
- Forms of cloacal retention.
- With the abdominal wall and the bladder split.
- With the bladder alone split.
- The bladder entire.
- Complex forms.
- Simple forms.

While such a classification of defects may serve for purposes of identification and for the arrangement of cabinets, it serves imperfectly its purpose as

a guide to their separate study. The ensuing pages will treat of the manner by which specimens of congenital or other defect can be most advantageously undertaken by the student. Every specimen should, when it is practicable, be carefully dissected, and from a single specimen of monstrosity several instructive anatomical preparations may be obtained.

The arrangement of the subject-matter in this portion of the book will be as follows:—

(A) *The parts of the embryo (Teratological Regions) in which defects occur.*

The teratological regions are six in number.

(1) The Blastodermic Membrane and its three Layers.

(2) The Region of the central Nervous System and of the Vertebral Column.

(3) The Region of the Alimentary Tract and of the Body Wall.

(4) The Region of the Omphalo-Mesenteric Tract and of the Allantois and Placenta.

(5) The Region of the Genito-urinary Apparatus.

(6) The Region of the Heart and the Visceral Arches.

(B) *The forces (Laws of Morphology) which underlie congenital malformation.*

(1) Gemmation.

(2) Parts which are arranged in Serial Order.

(3) In illustration of the law of Reversion.

(4) In illustration of the law of Symmetry.

(A) THE PARTS OF THE EMBRYO (TERATOLOGICAL REGIONS) IN WHICH DEFECTS OCCUR.

(1) The Blastodermic Membrane and its three Layers.—The ovum possesses a thick transparent wall called the vitelline membrane or *zona pellucida*. Within this and forming the great portion of its contents is a semi homogeneous substance termed the yolk or *vitellus*. Lodged in the vitellus, but out of its centre, is a rounded nucleus-like substance termed the *germinal vesicle*; and within this again a nucleolus-like particle, the *germinal spot*. Soon after the escape of the egg from the ovary and before impregnation, the germinal vesicle and germinal spot disappear; and at the same time on the periphery of the egg a rounded projection is formed opposite the locality at which the nucleus and nucleolar elements of the egg were situated. This projection, which is indifferently termed the *polar globule* or

polar vesicle, in time becomes constricted at its base, is cut loose from the egg, and is lost.

Coincidentally with this occurrence at the point where the germinal spot and germinal vesicle have disappeared, a structureless spot appears with lines of the granules of the vitellus arranged as radii toward it, the whole assuming a star-like form which has received the name of the *arch-amphiaser*, and which at the same time forms the *female pro-nucleus*, the latter being the name given to that portion of the egg which is alone susceptible of receiving the male impression.

The egg is now ready for the spermatic filament. This essential factor to the subsequent changes effects its entrance into the egg at a point opposite the position of the female pro-nucleus, and so modifies the disposition of the granules about a structureless centre as to form another arrangement, which, closely resembling the female pro-nucleus, has received the name of the *male pro-nucleus*. The pro-nuclei advance toward each other and merge at about the centre of the egg. Conception has now occurred.

The changes following conception are, first, segmentation; and, second, the formation of the blastodermic membrane.

Segmentation is the act of division of the vitellus into successively smaller and smaller masses. This begins by the vitellus forming two equal hemispheres, each hemisphere dividing in its turn, and each of these four parts again dividing. The process is continued until the entire vitellus is converted into a great number of minute spheres, which are called collectively the *mulberry mass*. The following is thought to be the manner after which the segmentation is accomplished.

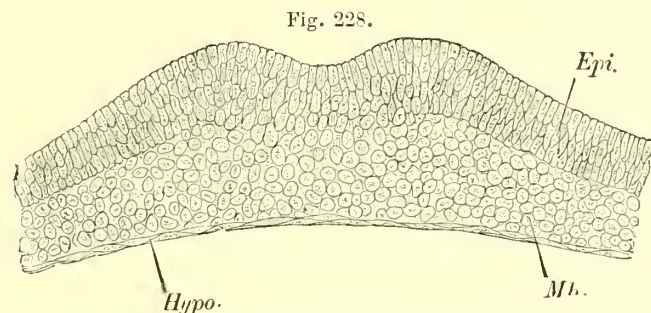
The conjoined pro-nuclei form a central star-like figure which tends soon to be bi-polar, each pole recalling the form of the amphiaser, and by traction on the intermediate substance causing it to assume a ribbed or lined appearance.

The granules of the vitellus range themselves about each of the polar amphiasers until there appears a nearly structureless space between the now localized hemispheres, along which fission occurs, and the intermediate substance between the amphiasers is severed in the centre. No sooner is the form of each hemisphere determined than the same process is repeated, the bi-polar disposition always occurring in the main axis of the mass. As a result of this method of division the essential quality of the impregnated egg is evenly distributed in such manner

that when the process ceases each of the spherules of the mulberry mass contains a portion of both male and female elements.

After complete segmentation the upper or dorsal portion of the egg is known as the *germinative area*. It is translucent, and in time is occupied by a sheet or layer of closely aggregated granules, which is called the blastodermic membrane.

The *blastodermic membrane* shortly undergoes horizontal cleavage into three layers (Fig. 228): the



Transverse section of blastoderm of fowl's egg at the situation of the primitive trace and primitive furrow—epiblast, mesoblast, hypoblast.

upper or epi-blast, the middle or meso-blast, and the lower or hypo-blast. Each of these develops certain organs of the body, which may be grouped thus:—

“The *epiblast* forms primarily two important parts of the body, viz., the central nervous system and the epidermis.

“It is from the involuted epiblast of the neural tube that the whole of the gray matter of the brain and spinal cord appears to be developed, the simple columnar cells of the epiblast being apparently directly transformed into the characteristic caudate nerve-cells. It is probable that the white matter of the brain and spinal cord is derived from the mesoblast alone. The epithelium (ciliated in the young animal) lining the *canalis centralis* of the spinal cord, together with that lining the ventricles of the brain, all which cavities and canals are derivatives of the primary neural canal, is the undifferentiated remnant of the primitive epiblast. From the epiblast are formed all such tegumentary organs or parts of organs as are epidermic in nature.

“In addition to these, the epiblast plays an important part in the formation of the organs of special sense. According to their mode of formation, these organs may be arranged into two divisions. In the first come the cases where the sensory expansion of the organ of special sense is derived from the involuted epiblast of the medullary canal. To this class belongs the retina, including the epithelial pigment

of the choroid, which is formed from the original optic vesicle budded out from the fore-brain. To the second class belong the epithelial expansions of the membranous labyrinth of the ear, and the cavity of the nose, which are formed by involution from the superficial epiblast covering the external surface of the embryo. These accordingly have no primary connection with the brain. It may be supposed that the 'taste bulbs' and the nervous cells which have lately been described as present in the epidermis are also structures formed from the epiblast. In addition to these the crystalline lens is formed of involuted epiblast and the cavity of the mouth lined by it.

"From the *hypoblast* are derived the epithelium of the digestive canal, the epithelium of the trachea, bronchial tubes, and air-cells, the cylindrical epithelium of the ducts of the liver, pancreas, and other glands of the alimentary canal, as well as the hepatic cells constituting the parenchyma of the liver, developed as we have seen from the solid hypoblast cylinders given off around the primary hepatic diverticula.

"Homologous probably with the hepatic cells, and equally of hypoblastic origin, are the spheroidal 'secreting cells' of the pancreas and other glands. The epithelium of the salivary glands, though these so exactly resemble the pancreas, is of epiblastic origin, inasmuch as the cavity of the mouth is lined by epiblast. The hypoblast also lines the allantois.

"From the *mesoblast* are formed all the remaining parts of the body. The muscles, the bones, the connective tissue, and the vessels, both arteries, veins, capillaries, and lymphatics with their appropriate epithelium, are entirely formed from the mesoblast. All the nerves of the body, both the cranial nerves (the so-called optic and olfactory nerves alone excepted), the spinal nerves, and the sympathetic system, are formed from the mesoblast. The nerve-cells of the sympathetic ganglia as well as those of the ganglia on the posterior roots of the spinal nerves are of mesoblastic origin, and thus apparently are in striking contrast with the nerve-cells in the brain and spinal cord. The fibres constituting the white matter of both brain and spinal cord are probably derived from the mesoblast.

"The generative and urinary organs are entirely derived from the mesoblast. It is worthy of notice that their epithelium, though resembling so closely the hypoblastic epithelium of the alimentary canal, is distinctly mesoblastic.

"From the mesoblast lastly are derived all the muscular, connective, and nervous and vascular ele-

ments, as well of the alimentary canal and its appendages as of the skin and the tegumentary organs. Just as it is only the epidermic moiety of the latter which is derived from the epiblast, so it is only the epithelium of the former which comes from the hypoblast."¹

REMARKS.—In the human subject any gross defect of the arrangements of the layers of the blastoderm will end in the death of the germ; little or nothing is known beyond this. In the lower animals a few observations have, however, accumulated.

Fol describes examples in the starfish of more than one spermatic filament entering the egg at or about the same time, resulting in irregular and defective unions between the female pro-nucleus and the multiple male pro-nuclei. The starfish possesses a transitional embryonic structure which, from its resemblance to the permanent arrangement of parts in the sponges and related animals, has received the name of the *gastrula*. The gastrula becomes deformed when a number of spermatic filaments effect their entrance into the egg. Individuals so deformed never attain to the succeeding stages of development.

Although nothing similar to the deformed gastrula has been observed in the higher animals, in the absence of other explanation the disturbing influence of an excess of sperm-force may be assumed to operate in all eggs, and it would appear to explain at least one form of monstrosity, viz., that in which two embryos, each having its own umbilical vesicle, and from that fact presumed to have its own portion of yolk-food, have been united by the crowns of the heads. (See Fig. 205.) It is here necessary to believe that two head-folds have appeared, not side by side, but with their convex surfaces apposed, each head-fold remaining intact. The ventral aspects of the two embryos in such a monster are not upon the same plane. Inasmuch as the ventral aspect is always on the under surface of the embryo it is likely that one of the embryos has undergone rotation from its original position. In some instances rotation to the extent of one-half of a circle has occurred, so that the face of one individual is upon the same plane as the occiput of the other. In other examples a quarter revolution has taken place, and the face of one embryo is presented to the plane of the profile of the other. Such malformations would not be apt to occur in creatures not possessing placental attachments; since, if the em-

¹ Quoted from "The Elements of Embryology," by M. Foster and F. M. Balfour, 197.

bryos were entirely dependent upon the yolk-sac for nourishment, they would be unlikely to present the ventral surface away from the underlying vitellus.

All errors of a gross character doubtless are announced at an early period in the history of the embryo, and the features attending the primal cleavage into the epiblast and hypoblast are probably modified at this time if defects of the central nervous system or of the genito-urinary apparatus are profoundly impressed. The errors of mesoblastic origin may prove to be of later origin; and owing to the more plastic character of this layer as compared to the more fixed character of the remaining layers of the blastoderm it is probable that even some acquired defects may be mesoblastic in nature. It would be a useful tentative position for the pathologist to accustom himself to view many forms of morbid growth, particularly the myxomata and sarcomata, as expression of mesoblastic development, occurring out of place and order.

The influence exerted in the formation of all structures from a well-defined layer of the blastodermic membrane probably persists throughout life, and it is a valuable hypothesis to assume that all such structures are apt to be associated in constitutional phases of diseased action. The subjoined illustrations are presented of this subject, which promise to be of interest in clinical and pathological studies. In congenital syphilis the following localities are often the seat of diseased action: The oral angle, the enamel caps, the nail-bed and nail, the retina, and the cornea. All of these structures are entirely of epiblastic origin excepting the cornea, which receives some mesoblastic elements in addition. Tumors which exhibit metastatic tendencies, that is, those which involve structures, secondarily by transfer of cells and tissue, fragments by the bloodvessels, are of hypoblastic origin. Among skin diseases, ichthyosis and psoriasis are included by E. Lesser¹ among the anomalies of the cuticle, and are of epiblastic origin.

The anus is lined with an involuted portion of epiblast from the perineum, while the rectum, excepting the portion near the anus, and the remaining portion of the alimentary canal, are of hypoblastic origin. It is interesting to note that the affections of the anus and rectum for an inch or so above the anus are in the main distinct from those of the remaining portions of the rectum and the alimentary canal. Metastatic conditions are unknown at the anus and the lower sixth of the rectum.—The mouth is lined with an in-

volution of epiblast, from a diverticulum of which the anterior lobe of the pituitary body is formed, while the pharynx, as stated by Balfour, is lined by a membrane of hypoblastic origin. It is observable that the separation of the two is sharply outlined at the oro-pharyngeal aperture. The oral region and the pharynx are thus embryologically distinct. The structural diseases of the mouth correlate with the cuticle, as, for example, the presence of hypertrophy of the gum with hirsute growths of skin; and some of the pharyngeal diseases, at least, with the deep-seated visceral chambers.—In connection with this phase of the subject may be mentioned the communication of the lymph-tracts of the roof of the pharynx with the lymph-spaces of the base of the brain. Diseases of the roof of the pharynx (conceding the foregoing premises to be well based) should be grouped in common with those of the pituitary body and of the base of the skull. The retention of osseous canals which extend from the pituitary fossa to the under surface of the basilar process may thus be made capable of a practical application;¹ and the presence of hairy growths from the sides of the pharynx, as described by P. S. Abraham,² by reason of their affinity with dermoid growths of the pituitary body, becomes of more than exceptional morphological interest.

(2) THE REGION OF THE CENTRAL NERVOUS SYSTEM AND THE VERTEBRAL COLUMN.

On the first day in the development of the cheek the epiblast sends up two ridges or folds upon the upper aspect, and in this way causes the outer surface of the egg to depart from the form of the sphere. These ridges are named the *medullary folds*, and the space between them *medullary groove*. The folds at one end unite to form the head fold, the posterior end of the groove remaining open. Behind the medullary groove, but not continuous with it, is a delicate linear depression, which is the so-called *primitive groove* or *primitive trace* (Fig. 228). It disappears in a little while without furnishing any clue to its significance. Foster and Balfour³ incline to the opinion that it is a rudiment of an early structure of some unknown ancestral form of life.

About the head fold and the medullary folds are developed the *proto-vertebræ* (under which name are

¹ See Axel Key and Retzius (Studien in der Anat. des Nervensystems und des Bindegewebes, Stockholm, 1875, 217–220, Taf. xxxvii.–xxxix.); also Waldeyer (Archiv f. microscop. Anat., xvii. 1880, 366).

² Journ. of Anat. and Phys., xv. 1881, 244.

³ Elements of Embryology, Part I. 50.

¹ Ziemssen's Handbuch, Hautkrankheiten, 470.

included the rudimentary and transitional hard parts arranged in the long axis of the embryo, under the position of the future vertebral column) (Fig. 229), the spine, and its contents.

Fig. 229.



Human embryo about one month old, showing the growth of the frontal process downward, and that of the superior and inferior maxillary processes from the side. The proto-vertebrae are distinctly shown.

REMARKS.—Defects of the cavity of the central nervous system are of two kinds: First, the defects arising within the nerve-matter itself, and second, those arising from the imperfect development of the walls of the skull and of the vertebral canal. Under the operations of the law that a deeply seated structure influences the development of the superficial parts whose function it is to cover in, and protect such structure (see p. 749), it will be seen, when both the deeply seated and inclosing structure arise from the same layer in the blastoderm—the epiblast—that the correlation between the rate of development of the two must be more than usually exact. In *spina bifida*, for example, in which condition, owing to the distension exerted by the fluids within the cerebral canal of the cord or its membranes, the medullary folds have failed to unite, the spinal cord itself is often defective. *Spina bifida* is more common at the lower portion of the vertebral column than elsewhere, but may involve the occiput.—In like manner the defects of brain-development correlate with corresponding defects in the vertex of the skull.

In *Acrania* the brain may be absent, and the skull be without vertex; or a mere rudiment of the brain may be found inclosed in a relatively large dorsal sac. The frontal and occipital portions of the vertex may be absent.

The condition known as *syringomyelus*, in which the central canal of the spinal cord is larger than usual, may be congenital, and relate to an imperfect closure of the medullary groove.¹

¹ See, in connection with this subject, F. Taylor, *Trans. Path. Soc. Lond.*, xxix. 1878, 21, and E. Leyden, *Virchow's Archiv*, lxxviii. 1. See also variations of the spinal cord, p. 470.

(3) THE REGION OF THE ALIMENTARY TRACT AND THE BODY-WALL.

At an early period the margin of the blastodermic membrane becomes thickened mainly by the increase of mesoblastic elements, and is cleft horizontally into two leaves. The inner of the leaves unites with the epiblast to form an inner tube, which constitutes the alimentary canal, its appendages, and the umbilical vesicle: from this circumstance it receives the name of the *splanchnopleure*. The outer of the leaves uniting with the hypoblast constitutes the body-wall of the embryo, particularly that of the thoracico-abdominal chamber, and has received the name of the *somatopleure*.—It will be noted that the striated muscle-fibres of the body-wall are of somatopleure-origin; and that the unstriated muscle-fibres of the abdominal tract are of splanchnopleure-origin.—The space between the splanchnopleure and the somatopleure is called the *pleuroperitoneal space*, and is lined with a serous membrane. This arrangement of parts persists with unimportant modifications in fishes, batrachia, reptiles, and in the majority of birds; but, in some birds and in mammals, the Diaphragm intervenes between the thoracic and peritoneal spaces.

REMARKS.—Among the defects of the *somatopleure* may be mentioned the following: The entire *abdominal wall* may be absent and the intestines be exposed or protected by the parietal peritoneum only. The urachus may persist, and the abdominal wall from the navel down to the pubis be imperfect or absent. Herniæ of the liver and intestine frequently occur, especially at the position of the umbilicus, which even in slight degrees of defect of the abdominal wall is liable to be larger and more patulous than is normal, and to aid in maintaining intestinal protrusions.

In the chest the *sternum* may be absent, from which the variety of defect known as *Ectopia cordis* is derived.—The Diaphragm may be absent.—In lateral duplication of parts the thorax is variously deformed.

The presence of diverticuli of the intestine, and the union of a diverticulum with the umbilicus may be accepted as errors of development of the *splanchnopleure* and its ducts. In like manner the general history of the variations in the alimentary canal and its appendages may be referred to the impress made upon the embryo at the time of the appearance of the splanchnopleure.

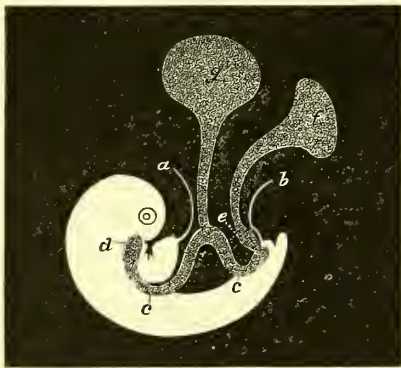
This subject of retained omphalo-mesenteric vessels

and diverticuli as causes of intestinal obstruction has been elaborately elucidated by R. H. Fitz.¹

(4) THE REGION OF THE OMPHALO-MESENTERIC TRACT, OF THE ALLANTOIS AND THE PLACENTA.

This includes the nutritive, circulatory, and respiratory systems of the embryo. The blastodermic membrane is nourished by the lower layer of hypoblastic cells sending protoplasmic processes into the umbilical vesicle. A marginal extension of the hypoblast and the splanchnopleure incloses the vesicle, and the contents are gradually appropriated. The remains of the umbilical (Fig. 230) vesicle are known as the *splanchnic*

Fig. 230.



Formation of the alimentary canal. *a b*, Commencement of the amnion; *c c*, intestines; *d*, pharynx; *e*, urinary bladder; *f*, allantois; *g*, umbilical vesicle.

stalk. When the foetus secures attachment to the walls of the uterus these remains are held to the under surface of the foetus by a long thin pedicle.

The umbilical vesicle disappears as development progresses in the pig, the mare, the cetaceans, and the ruminant types, so that no trace of it can be seen in the membranes of the advanced embryo. In the carnivorous animals, including the seals, it forms a well-defined sac in relation to the abdominal sac of the foetus situated between the allantois and the amnion. In the rabbit the umbilical vesicle reaches the chorion and forms a large sac in contact with a considerable portion of that membrane.²

While, however, this process of absorption is going on, a system of vessels is developed within the mesoblast of the embryo which supplants the protoplasm of the hypoblast in the work of carrying up into the embryo the liquefied contents of the umbilical vesicle.

¹ Am. Journ. of Med. Sci., N. S. clxxv. 1884, 30, literature; see, also, variations of superior mesenteric artery and the omphalo-mesenteric artery, p. 395, and of the general consideration of veins, p. 411 of this book.

² Introduction to Human Anatomy, W. Turner, 865.

This system of vessels has received the name of the *omphalo-mesenteric system*. In time yet a third set of vessels is required (since the umbilical vesicle in mammalia at least is of temporary use only, and is not adapted for respiratory purposes), which is developed through the *allantois*, an account of which structure necessitates some understanding of the membranes of the egg, for it is through the medium of the membranes that the allantois proves so efficient as an appendage to the circulatory and the respiratory systems.

To the outer side of the medullary fold from the upper surface of the blastoderm, a pair of folds arise containing epiblastic and mesoblastic elements which from their future use in forming the amnion are called the *amnionic folds*. Each of the amnionic folds approaches the median line over the position of the medullary folds, and by fusing with the corresponding fold on the opposite side of the median groove inclose the embryo in a special chamber—the amniotic chamber—which is eventually lined with epiblastic pavement epithelium cells, and secretes the amniotic liquid (*liquor amnii*) (Fig. 231). The connection of

Fig. 231.



Human embryo and its membranes in the early period of gestation, showing the formation of the umbilical cord.

the amnion with the nutritive system of the foetus is not included in this plan. To account for such inclusion it should be remembered that before the amniotic folds meet a lateral growth of each fold is also announced which gradually underlies the zona pellucida in its entire extent, and constitutes the *subzonal* membrane (serous envelope) of the ovum (see Fig. 237).

The wall of the impregnated egg is called the *chorion*. By the time development has so far advanced as to present an amniotic chamber, the chorion is everywhere covered with a great number of villus-like processes, and is said to be *shaggy*.

In order to show the significance of the shaggy chorion it is necessary to study some of the later changes in the interior of the egg. After the amnion is formed, and the splanchnopleure is determined, a small bud-like process is projected from the hypoblast, and appears upon the under surface of the embryo between the umbilical vesicle and the sub-zonal layer. This is the *allantois*.

Fig. 232.



Diagram of the embryo and its vessels, showing the circulation of the umbilical vesicle; and also that of the allantois, beginning to be formed.

The allantois grows downward and outward increasing in size as the umbilical vesicle diminishes, and tends to approach the sub-zonal layer, and, expanding as it does so, unites by a relatively broad surface of contact with the layer last named and through it with the shaggy chorion, while its point of origin remains narrowed and stem-like. The abdominal vessels pass freely into the allantois, and by the time its development is completed it is very vascular.

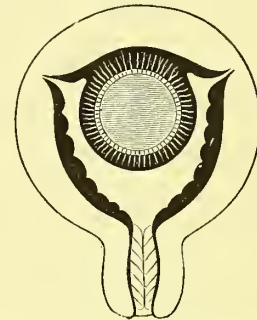
The allantois is thus a projection of mesoblast containing a lining membrane of hypoblast. Its walls define a space which is known as the *allantoic space*, and is filled with fluid—the *allantoic liquid*.

The pedicle of the allantois is at a later period continuous through the urachus with the urinary bladder, and, at a time when the abdominal viscera are developed, the pedicle of the allantois becomes the umbilical cord.

Uterine changes incident to pregnancy.—The egg in the time during which the above-named changes have been effected has passed from the Fallopian tube into the uterus, the walls of which are peculiarly prepared for its reception. Instead of being smooth they are now tufty; instead of being firm they are now soft and yielding. The egg is soon arrested by its own villous processes which catch upon the inequalities of the soft lining membrane of the uterus, and its further descent prevented.—The uterine membrane now em-

braces the egg, and retires it, as it were, from the general uterine cavity (Fig. 233).

Fig. 233.

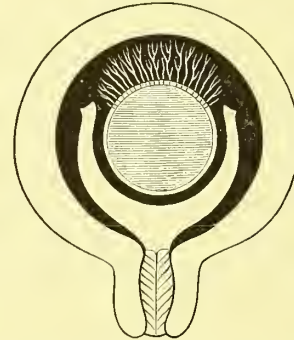


Impregnated uterus, showing the connection between the villousities of the chorion and the decidual membranes.

A few terms which require definition are employed in describing the relations between the uterus and the impregnated egg.

The whole lining membrane of the uterus in its peculiar changed condition due to the influence of an impregnated egg descending the Fallopian tube, is called the *membrana decidua*. That portion of the membrane lining the uterus other than the surface of contact of the egg is called the *membrana decidua vera*; that portion at which the contact takes place between the egg and the uterine wall is called the *membrana decidua seritona*; and that portion inclosing the egg is called the *membrana decidua reflexa* (Fig 234.)

Fig. 234.



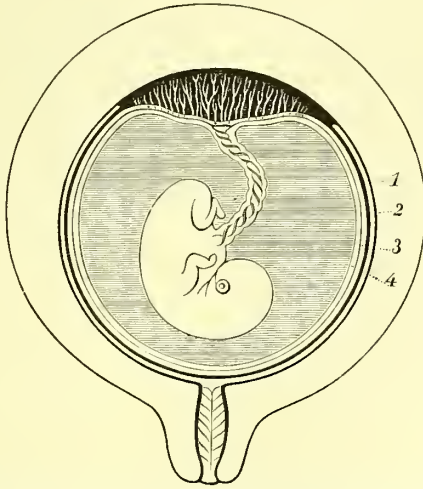
Pregnant uterus, showing the formation of the placenta by the local development of the decidua and the chorion.

The surface of contact of the allantois with the chorion so influences the nutritive processes in the latter membrane that the villi of the shaggy coat at this place effect firmer union with the uterine membrane than elsewhere. Indeed at all points other than the one indicated the villous processes disappear.

The Placenta is the result of modifications excited

between the retained patch of shaggy chorion and the *membrana decidua serotina* (Fig. 235).

Fig. 235.



Pregnant human uterus and its contents, about the end of the seventh month, showing the relations of the cord, placenta, and membranes. 1, Decidua vera; 2, decidua reflex; 3, chorion; 4, amnion.

The placenta serves as the medium of interchange of nutritive and excreted material during pregnancy. At birth the attachments are loosened; the placenta (foetal placenta) is severed from the uterine wall (maternal placenta), and comes away as so much useless material. From the moment of its severance the infant requires nourishment through the channels which characterize all forms of extra-uterine existence.

The *structure* of the placenta has been made the subject of special study by many accomplished anatomists since the time of William Hunter, and it yet remains in some particulars a subject of controversy. The following description, abridged from an account¹ by Prof. Turner, is herewith introduced.

The relation of the foetal and maternal portions of the placenta can be best studied at about the fifth month, when the decidua reflex and villi, connected with the non-placental area of the chorion, have atrophied, and the villi in the placental area have undergone a great increase. Well-marked bars or dissepiments of decidua serotina pass through the thickness of the placenta as far as the chorion, and divide it into lobes or cotyledons. These bands and their subdivisions and separate trabeculae form the *serotinal membrane*, which, giving rise to still more delicate offshoots, forms a minute intra-placental trabecular arrangement in the interstices of which the villi are

lodged. The maternal bloodvessels are now dilated into sinuses, and are also prolonged into the placenta along the cellular structures of the decidua serotina, so that the dilated vessels of the modified uterine mucous membrane are brought into relation with the vascular villi of the foetal chorion. The placenta when matured presents the appearance of a disc-shaped spongy cake, which measures from seven to nine inches in diameter, and about one inch in thickness; toward its circumference it is somewhat thinner. The inner (chorionic) surface exhibits ramifications of the umbilical vessels, and is closely covered on its foetal side by the amnion; from its placental (outer, serotinal) side multitudes of arborescent vasculi villi arise (Fig. 236).

Fig. 236.



Diagram of the embryo and its vessels, showing the second or placental circulation. The intestine has become further developed, and the mesenteric arteries have enlarged, while the umbilical vesicle and its vascular branches are reduced in size. The large umbilical arteries are seen passing out to the placenta.

The arrangement of the bloodvessels in the decidua serotina is as follows: The peculiar tortuous arteries of the decidua—the *curling arteries*—are continuous with the convoluted uterine arteries. They pierce the decidua serotina, and open upon the placental surface. The veins of the decidua serotina are directly continuous with the mouths of the curling arteries. These veins—the utero-placental veins—form an extensive series of large *cavernous spaces* (placental sinuses, lacunae, placental cells, inter-villal spaces, placental bag or sac) which freely communicate one with another, not only in a single lobe, but in adjacent lobes through imperfections in

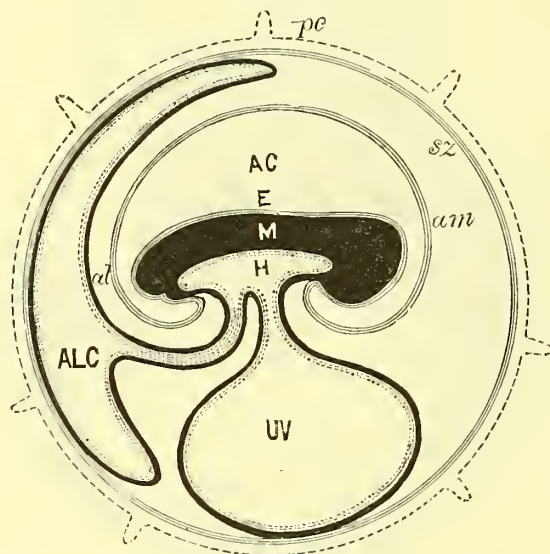
¹ Manual of Anatomy, 874.

the dissepiments. Each cavernous space, as it forms the boundaries of the depressions for a choroidal villus, is lined with a single layer of oval epithelial cells; this acts as a secreting surface, and separates and prepares a secretion from the maternal blood which is absorbed by the vessels of the chorionic villi, and applied to the nutrition of the foetus.

The placenta is a compound organ, and consists of two series of structures, the one belonging to the foetus, the *foetal placenta*; the other to the mother, the *maternal placenta*. The foetal placenta is formed of the chorion, amnion, allantois, and umbilical vessels.

The *chorion* (primitive chorion, zona pellucida) is the outmost membrane of the egg.

Fig. 237.



A diagrammatic representation of the fetal membranes. E, Epiblast; M, mesoblast; H, hypoblast; UV, umbilical vesicle; *al*, allantois (the allantois lies to the left of the letters); *am*, amnion (the amnion lies to the left of the letters); AC, the amniotic chamber; ALC, the allantoic chamber; *sz*, the subzonal membrane; *pe*, the primitive chorion with villi.

REMARKS.—The effects of inflammatory adhesions between the integument and the amnion have been noted on p. 749.—The *decidua vera* and *decidua serotina*, together with inclosed embryo, may be arrested in development, and constitute the so-called placental mole, which in time is expelled from the cavity of the uterus.—The subject of ectrophy of the bladder (see p. 765) involves the pedicle of the allantois, and has close relations to the bloodvessel system of the embryo.

THE REGION OF THE GENITO-URINARY APPARATUS.

The Genito-Urinary tract embraces the organs occupying a position between the peritoneal sac and

the vertebral column, and those parts of the nutritive system by means of which the allantois assists in the formation of the urinary bladder.

The teratological region embraced by this apparatus extends along the entire length of the retro-peritoneal space of the adult, and in addition includes the ureter, the bladder, the internal and external organs of generation, as well as the rectum, in its middle and lower portions, and the anus. This extensive tract possesses in common the following embryonic features:—

The Wolffian Body.

The Kidney.

The Ovary.

The Testis.

The External Organs of Generation.

The Bladder and Urachus.

The Prostate Gland and Duct of Gartner.

The Wolffian Bodies.—The genito-urinary apparatus, unlike other anatomical systems, possesses an embryonal structure, in many respects unlike the one permanently assumed. A single structure, termed the Wolffian body, lies in the retro-peritoneal space in the position of the future kidney, and, indeed, performs the work of that gland; at the same time it holds within itself the groove from which both the male and the female genito-urinary organs are derived.

According to the researches of Semper and Balfour, the primordial organ, which arises from the *intermediate cell-mass of the mesoblast*, is composed of three distinct portions, the anterior (pronephros), the middle (mesonephros), and the posterior (metanephros). Of these, the middle portion alone forms the Wolffian body, while the posterior becomes the future kidney; the anterior portion is of obscure function and destiny in the higher animals, and need not here be regarded.

The Wolffian bodies are two elongated tubular masses of a reddish color, found lying in the retro-peritoneal space. The tubuli are arranged transversely from within outward, and empty into a *duct* (Wolffian duct), which runs vertically downward along the outer side of the body to the primitive cloaca. Towards the initial ends of the tubuli, at the lower portion of the Wolffian body, a number of minute structures are seen, which resemble in form and function the Malpighian corpuseles of the kidney.

After an activity ranging from the sixth to the seventh week the Wolffian bodies atrophy, in time disappear, and the subsequent work of excretion during foetal life falls upon the kidneys.

A few insignificant structures in adult life are identified with portions of the Wolffian body. In the male the organ of Giraldès, the hydatid of Morgagni, and the vas aberrans have this significance, and, in the female, portions of tubuli persist, constituting the parovarium, which lies in the broad ligament near the uterus, and the so-called grains of Folio, which lie near the uterus.

In the sow, some of the ruminant and quadrumanous types, the lower portion of the organ, constituting the duct of Gærtner, also persists. This rudiment is generally described as absent in the human female, but C. Rieder¹ has detected its presence as often as in one out of every three dissections. In one-fifth of these instances it is found as a small tube, extending either parallel to the upper portion of the vagina, or embraced in the muscle-fibres of the cervix uteri, and is lined with cylindrical epithelium. The author thinks it probable that some forms of vaginal cyst take their origin in this rudiment.

In the course of development of the ovary and the testis and the passages with which they are in association, the intermediate mass yields the following structures.

In the development of the testis the parenchyma arises from the stratum beneath the germ epithelium, and exhibits as early as the seventh or eighth week the characteristic tubuli, which are lined with cells (seminal cells) held to be homologous with the germ-epithelium of the ovary. The proper Wolffian duct constitutes the vas deferens and the ejaculatory duct. The vesicula seminalis is formed as an outgrowth from the lower part of the duct. From a specimen of abnormal development described by Turner, in which the globus major was alone absent in the excretory apparatus, it was inferred that this portion of the duct has a distinct development, and probably arises from a separate portion of the intermediate mass which, according to Cleland and Banks, remains distinct from the Wolffian body, and evolves the vasa efferentia, the areus vasculosa, and the globus major.

The ovary is a differentiation of the median portion of the Wolffian body. It consists of two portions, a stroma and an investing epithelium. The epithelium receives the special name of the *germ-epithelium* of Waldeyer. The ova, which appear at an early period of development, arise from the germ-epithelium, but as they become differentiated are depressed beneath the germ-layer and received in special sacs,

(ovi-sacs, Graafian follicles), which arise within the ovarian stroma. The ovary, unlike the testis, is not continuous with its duct; but lies in the peritoneal chambers and in the neighborhood of the initial end of the Fallopian tubes, the fimbriated extremity of which is homologous again with the hydatid of Morgagni. The Fallopian tubes, the uterus, and the vagina constitute special differentiated chambers or sacculations along the course of a single tube which is held to be homologous with the Müllerian duct which lies adjacent, and to the median side of the Wolffian body.

In both sexes the Müllerian ducts and the Wolffian duct are inclosed at their lower portion in a common investing mass which has received the name of the *genital cord* (uro-genital cord). The ducts of Müller coalesce in a portion of their course, but subsequently become distinct. In the female this coalesced portion represents the body of the uterus and the vagina. In the male the Müllerian ducts disappear excepting the vestigial structures which persist in the *hydatid of Morgagni*, and in the terminal portion of the coalesced ducts where they join the urethra is the prostate gland, which has received the name of the *uterus masculinus* (pouch of Weber, vesicula prostatica).

Two interesting cases of union of the ureter and vesiculæ seminales are reported by C. E. E. Hoffmann.¹ The article contains literature of the entire subject of uretral malformation.

The Urinary Bladder and Urachus. The bladder is a pouch developed from the allantois as it projects from the trunk. It is, therefore, of necessity continuous with the stem of the allantois upward and through the navel at the time of the formation of the placenta. Much later, after the elements of the allantois are no longer recognized in the umbilical cord, the connection between the urinary bladder and the navel persists in the form of an open tract termed the urachus (see Bladder, p. 704). The bladder opens in both males and females by the urethra into the uro-genital sinus. The urachus closes after birth, but the bladder retains the elongated form due to the origin of the bladder during childhood.

In *ectrophy of the urinary bladder* the abdominal wall is fissured from the umbilicus to the pubis. The hypogastric region is much smaller than is normal, since the umbilicus is carried to a point near the pubis. The urachus is absent. The only portion of the bladder which has developed is the lower portion

¹ Virchow's Archiv, 1884, xevi., 100 (fig.).

¹ Archiv d. Heilkunde, xiii. 522, Taf. vii.

of the posterior wall and the *bas fond*. The mucous membrane of the viscus projects at the fissure as a convex swelling, and bears the papillæ of the ureters, from which the urine intermittently trickles. The symphysis pubis is not completely closed. In males the testicles are either retarded in their descent, or, if they lie within the scrotum, congenital scrotal hernia coexists; the penis is rudimentary. In females the urethra and clitoris are absent, and the vestibule is either narrowed or is closed; the vagina also may be absent. The essential structures of the genito-urinary tract remain as a rule unaffected.

W. Atlee¹ narrates a case in which the question of dilated urachus entered into the question of diagnosis of ovarian tumor.²

The External Organs of Generation. Up to the seventh or eighth week the intestinal canal, the ureters, the Müllerian and Wolffian ducts empty into a common chamber, which opens at the inferior pelvic outlet which receives the name of the *cloaca*, an arrangement which persists in reptiles and birds, and the lowest of the mammalia. Subsequently the rectum opens by a separate outlet—the anus—but the genito-urinary apparatus opened in a separate chamber—the *uro-genital* sinus. At this period the perineum exhibits two openings in both sexes, a posterior, which is the *anus*, and an anterior, which is the outlet of the *uro-genital* sinus.

The external organs of generation are about the same time developed from an indifferent type. Prior to the eighth or ninth week, the penis or clitoris is slightly projected from a circular pad of skin. The penis or clitoris exhibits a cleft beneath which communicates with the aperture of the *uro-genital* sinus. Beyond the period named the external differences in sex announce themselves. In the female the clitoris is determined by the persistence of the aperture of the *uro-genital* sinus. The sides of the cleft beneath the organ form the labia minora, which aid in defining the vestibule. The circular pad of integument and fat, shaping itself as the labia majora. In the male, the penis is determined by the closure of the aperture of the *uro-genital* sinus, and the obliteration of the groove on the under surface of the organ. The pad of skin is converted into the scrotum, which subsequently receives the testis.

REMARKS.—Errors of development of the organs of generation may be grouped as follows:—

The Wolffian bodies, instead of forming organs of the same sex, may form the parts comparable to those of a male on one side, and those of a female on the other. This malformation constitutes true or lateral hermaphroditism, and is an exceedingly rare variety of that condition. It has been observed in the hog, the ox, and in man.

The Wolffian bodies are normally metamorphosed to male organs, but the external parts are imperfectly developed. Thus, an empty scrotum exists which resembles in form and position the labia majora; a rudimentary penis is seen which recalls the form of the penis; it is usually imperforate or hypospadiæ. The *uro-genital* sinus may persist as a narrowed infolding of the integument suggestive of a vagina. The secondary signs of virility, such as the beard, and the hair on the hypogastric region, are absent. The voice is not sonorous, nor is attraction to the opposite sex, as a rule, acknowledged. Should the *uro-genital* sinus be capacious, however, the person may pass for a female, and submit to intercourse as such. Dissection of the body reveals small and imperfectly descended testicles.

The Wolffian bodies may be normally metamorphosed to female organs, while the external parts are imperfectly developed. In such aberrant forms the clitoris is larger than in the normally developed female, the vagina may be absent or small, and retain the appearance of a narrowed *uro-genital* sinus. When examined with care a rudimentary uterus may be detected. The superficial phenomena of menstruation are often present. A sparse beard may exist, the voice is harsh, the disposition masculine. The individuals frequently pass for men, and may have intercourse as such. Dissection shows normally situated ovaries, but the Fallopian tubes may be rudimentary and closed.

The internal organs of generation may be normal and the penis or clitoris be properly defined, but the *uro-genital* sinus may persist and include the lower portion of the rectum. Or the sinus may, as is normal, disappear and with it all external orifice of the rectum. The latter malformation is known as *congenital imperforate rectum*.

According to O. Beumer,¹ malformation of the genital organs is frequently associated with absence of one kidney. This is seen to be natural enough when it is remembered that the internal organs of generation arise from the same portion of the embryo as the kidneys. An early impress of malnutrition in

¹ Ovarian Tumors, 50.

² For an account of the development of the Kidney in man and the lower animals, see Toldt, Proc. Wien. Acad., 1874, 123.

¹ Virchow's Archiv, lx., 1874, 1; Taf. 1.

the undifferentiated tissue of this region would be apt to influence the entire uro-genital tract.

Kidneys.—For variations of the kidneys, see p. 700.

THE REGION OF THE HEART AND THE VISCERAL ARCHES.

The development of the heart and the visceral arches can be conveniently associated.

“At the extreme end of the embryo, where the blastoderm begins to be folded back, the mesoblast is not cleft, and here consequently there is neither somatopleure nor splanchnopleure; but at a point a very little further back the cleavage begins, and the somatopleure and splanchnopleure diverge from each other. They thus inclose between them a cavity which rapidly increases behind. Both folds are turned round again and then course once more forward over the umbilical vesicle. As they thus return (the somatopleure having meanwhile given off the fold of the amnion) they are united again to form the uncleft blastodermic investment of the umbilical vesicle. It is in this cavity, which from its mode of formation the reader will recognize as a part (and indeed at this epoch it constitutes the greater part) of the general pleuro-peritoneal cavity, that the heart is formed.

“It makes its appearance at a point where the splanchnopleure folds turn round to pursue a forward course, and by the end of the first half of the second day has acquired somewhat the form of a flask with a slight bend to the right. At its anterior end a slight swelling marks the future *bulbus arteriosus*, and bulging behind indicates the position of the *auricles*. It is hollow, and its cavity opens below and behind into two vessels called the *omphalo-mesaraic* veins (omphalo-mesenteric) which pass outwards in the folds of the splanchnopleure at nearly right angles to the axis of the embryo. The anterior extremity of the heart is connected with the two aortæ.

“Soon after its formation the heart begins to beat, its pulsations are at first slow and rare, beginning at the venous and passing on to the arterial end. It is of some interest to note that its functional activity commences long before the cells of which it is composed show any distinct differentiation into muscular or nervous elements. To provide channels for the fluid thus pressed by the contractions of the heart, a system of tubes has made its appearance in the mesoblast both of the embryo itself and of the vascular and pellucid areas. In front the single tube of the heart bifurcates into two *primitive aortæ*, which pass from its under to its upper side, the two forming together a sort of incomplete arterial collar imbedded in the mesoblast of the gut. Arrived at the upper side of the beginning of the alimentary canal they turn sharply round, and run separate but parallel to each other backwards towards the tail, in the mesoblast on each side of the notochord immediately under the pro-vertebræ. About half way to the hinder extremity each

gives off at right angles to the axis of the embryo a large branch, the *omphalo-mesenteric*, which, passing outward, is distributed over the pellucid and vascular areas, the main trunk of each aorta passing on with greatly diminished calibre towards the tail, in which it becomes lost.”¹

The aortic bulb yields a number of branches which form in the embryo, the system of the aortic or branchial arches. The study of the variations of these arches has already been considered (p. 348). In this place it is designed to show that they are associated in turn with the structures of the head rather than with the trunk, and that as the heart itself is originally a cephalic structure so the defects of this organ and those of the branchial system of blood-vessels should not only be studied together but should embrace the study of the visceral arches as well.

The Visceral arches (branchial arches) are five pairs of buds which appear as buds from the base of the skull, and which project downward on either side of the oval and pharyngeal spaces to join at the median line of the neck. Each arch carries a branch of the aortic system, and is most intimately associated in the plan of the arrangement of the system of vessels in the foetus and in some batrachians. In this manner the development of the skull is seen to be in part correlated with the development of the heart and is part of the great vessels.

“It must be borne in mind that, especially in the early stages of development, owing to the very unequal growth of different parts, the relative position of the various structures is continually shifting. This is very well seen in the instance of the heart. At its first appearance, the heart is lodged immediately beneath the extreme front of the alimentary canal so far forward as to underlie that portion of the medullary canal which will form the brain. It is, in fact, at that epoch a part of the head. From that early position it gradually recedes farther and farther backward, until, at the end of the third day, a considerable interval is observed between it and the actual head. In other words, a distinct neck has been formed, in which most important changes take place.

“The neck is distinguished from the trunk in which the heart now lies by the important feature that in it there is no cleavage of the mesoblast into somatopleure and splanchnopleure, and consequently no pleuro-peritoneal cavity. In passing from the exterior into the alimentary canal, the three layers of the blastoderm are successively traversed without any breach of continuity save such as is caused by the cavities of the bloodvessels. In this neck, so constituted, there appear on the third day certain fissures or clefts, the *visceral* or *branchial clefts*. These are real clefts or slits passing right through the walls of the throat, and are placed

¹ Foster and Balfour, l. c., 63.

in series on either side across the axis of the alimentary canal, lying not quite at right angles to that axis and parallel to each other, but converging somewhat to the middle of the throat in front. Viewed from the outside in either fresh or preserved embryos they are not very distinctly seen to be clefts; but when they are seen from within after laying open the throat, their characters as elongated oval slits can easily be recognized.

"Four in number on either side, the most anterior is the first to be formed, the other three following in succession. Their formation takes place from within outwards. The hypoblast and mesoblast are first absorbed along the line of the future cleft, then the epiblast is broken through, and the hypoblast, which is carried outwards as a lining to the slit, forms a junction with the epiblast at the outside of the throat.

"No sooner has a cleft been formed than its upper border (*i. e.*, the border nearer the head) becomes raised into a thick lip or fold, the *visceral* or *branchial fold*. Each cleft has its own fold on its upper border, and in addition the lower border of the fourth or last visceral cleft is raised into a similar fold. There are thus *five* visceral folds to *four* visceral clefts. The last two folds, however, and especially the last, are not nearly so thick and prominent as the other three, the second being the broadest and most conspicuous of all. The first fold meets, or nearly meets its fellow in the middle line in front, but the second falls short of reaching the middle line, and the third, fourth, and fifth do so in an increasing degree. Thus in front views of the neck a triangular space with its apex directed towards the head is observed between the ends of the several folds.

"Into this space the pleuro-peritoneal cavity extends, the somatopleure separating from the splanchnopleure along the ends of the folds; and it is here that the aorta plunges into the mesoblast of the body.

"Of the history of these most important visceral folds and clefts we shall speak in detail hereafter; meanwhile we may say that in the chick and higher vertebrates the first three pairs of folds are those which call for most notice.

"The first fold on either side, increasing rapidly in size and prominence, does not, like the others, remain single, but sends off in the course of the third day a branch or bud-like process from its upper edge. This branch, starting from near the outer beginning of the fold, runs forward and upward, tending to meet the corresponding branch from the fold on the other side, at a point in the middle line nearer the front of the head than the junction of the main folds. The two branches do not quite meet, being separated by a median process, which at the same time grows down from the extreme front of the head, and against which they abut. Between the main folds, which are directed somewhat downward and the branches which slant upward, a somewhat lozenge-shaped space is developed which, as the folds become more and more prominent, grows deeper and deeper. The main folds are the rudiments of the *inferior maxillæ*, the branches those of the *superior maxillæ*, the lozenge-

shaped cavity between them is the cavity of the mouth, and the descending process which helps to complete the upper margin of this cavity is called, from the parts which will be formed out of it, the *fronto-nasal process*.¹

The visceral arches are first the *mandibular* which accommodates an axial rod of cartilage about which is developed the lower jaw; second, the *hyoid* which yields the parts of the hyoid apparatus; third, fourth, and fifth are not separately named, though the first has been called by some writers the *thyro-hyoid*. Their destiny in the history of the development of the neck is obscure.

It has been seen that the head develops about the *head fold* of the medullary ridge. The line of pro-tovertebræ and the special notochord extend as a rod into the base of the skull as far as the anterior end of the basilar portion of the occipital bone. The notochord is formed prior to both cartilage and bone, but appears to suggest a substance related thereto. The rod becomes converted into cartilage yielding distinctive buds which pass forward from the region at which the rod terminates. A median extension, or bud, composed of coalesced *trabeculæ cranii*, enters the region of the face, and forms the nasal septum, the crista galli, and the lateral portions of the ethmoid bone. Prior to this coalescence of the trabeculæ, they inclose a space called the pituitary space, into which the infundibulum and the pituitary gland extend.

The trabeculæ have been supposed by some observers to be comparable to a pair of visceral arches. They are, as has been seen, outgrowths from the cartilaginous investment of the notochord, while the visceral arches are related to the mesoblastic masses about the aortic system of vessels, although carrying axial rods of cartilage later. While thus differing in origin they are alike in the assistance they give to the development of the face and neck. From the trabeculæ are probably developed the inner pterygoid plate, the palatine bone, the lower turbinated bone, and portions of the maxilla.

While the lateral structures, seen in the plates from which the maxillæ and the halves of the mandible arise, are extending toward the median line, the superficial median structures which conform to the position of the olfactory vesicle and the cerebral vesicle become conspicuous. These structures include the nasal pit and the fronto-nasal process (Fig. 229).

"Over each olfactory vesicle the external epiblast which covers them grows inward to form a shallow depression with a thickened border. These depressions are the *nasal pits*.

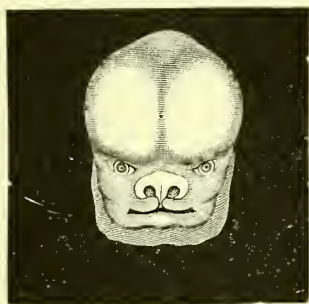
¹ Foster and Balfour, *l. c.*, 118.

"The two nasal pits on the third day are shallow depressions with thickened borders complete all round. As the pits deepen on the fourth day by the growth upward of their rims, a break is observed in each rim in the form of a groove directed obliquely downward towards the cavity of the mouth."¹

The fronto-nasal process is on the third day a superficial projection caused by the bulging anterior extremities of the vesicles of the cerebral hemispheres; on the fourth day it becomes more prominent, separates the nasal pits from each other, and aids in forming the inner wall of each.

"Abutting on the outer side of each groove and so helping to form the outer wall of each, lie the ends of the superior maxillary processes of the first visceral arch, which like the fronto-nasal process are increasing in size. By their continued growth, the groove is more and more deepened, and leading as it does from the nasal pit to the cavity of the mouth, may already be recognized as the rudiment of the passage of the posterior nares."²

Fig. 238.



Head of human embryo at about the end of the second month.

Fig. 239.



Head of human embryo about the sixth week.

The mouth is seen to be a space intervening between the maxillary and mandibulous plates and is lined with epiblast. It does not connect at first with the alimentary canal.

REMARKS.—The brain may be in a rudimentary condition, especially the cerebrum, which may remain smooth without hemispheres, olfactory bulb or basal ganglia. With this condition the ethmoid bone is undeveloped, the fronto-nasal process descends imperfectly if at all, the maxillary plates fail to meet the premaxillæ, and are separated by a median fissure of the upper lip. The eyes approximate, and may even merge into one. This malformation constitutes *cyclops*. The maxillary plate of one side (commonly the left) may fail to unite with the corresponding pre-maxilla to constitute *single harelip*, or both may

fail to effect their accustomed union, forming as a result *double harelip*. Either of these may be associated with partial or complete cleft of the hard and the soft palate.

The fronto-nasal process may ascend instead of descending, the maxillary plate may nearly unite by reason of the absence of the premaxillæ, when a genuine harelip results, *i. e.*, a cleft which answers to the space between the maxillary plates in the median line. Or the fronto-nasal process may descend and an opening exist on either side as a result of failure of the maxillary plate to unite with the process in question. The palpebral fissures may be continuous with the mucous membrane intervening between the cheeks and the sides of the external nose.¹—The nose may be absent on one side of the face alone. This condition, which has received the name of *Arhinencephala unilateralis*, is associated with absence of the cribriform plate of the corresponding side. A pendulous tumor from the region of the internal canthus of the affected side has been described by A. Selenkoff.²

The mandibular arches may infrequently fail to unite, and cyst-like spaces indicate the interspaces between the ends of the imperfect parts. Richet³ and J. Jardine Murray⁴ have described *dermal crypts* in the lines of defective growth of the jaws.—The defects of the visceral arches upon the neck are exceedingly rare. They are indicated by the presence of *fistulous tracts* which open upon the surface at one or more points of the neck. It is inferred that such tracts are due to imperfect closure of the third or fourth visceral clefts. Cervical fistulæ may communicate with the trachea and the œsophagus. They have been found both on the right and the left side, and at the median line. J. M. Duncan⁵ describes a case of a boy aged sixteen years, in whom a reddish spot less than a pin's head in size was situated above the insertion of the sternal portion of the right Sterno-Cleido-Mastoideus muscle. A small quantity of fluid escaped daily. In infancy, milk trickled from the opening when the child was at the breast. The condition was held by the reporter to be a congenital fistule connecting with the œsophagus.

Since the visceral cleft between the mandibular and the hyoid arches extends upward to the ear, and

¹ For additional case and figure, see R. Harley, Trans. Obs. Soc., iv. 213.

² Virchow's Archiv, 1884, xcv. 95.

³ Gaz. Hôpitaux, 1861, 174.

⁴ Br. and For. Med.-Chir. Rev., 1860, xxvi. 502.

⁵ Edin. Med. Journ., i., 1855, 426.

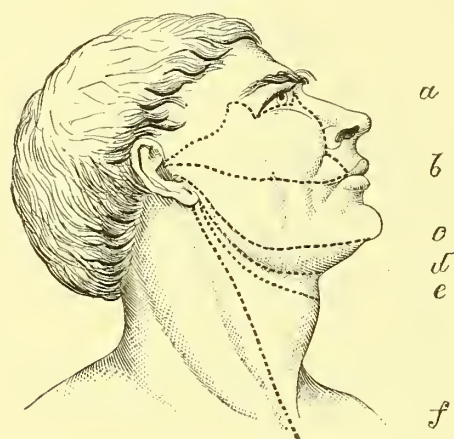
¹ Foster and Balfour, l. c. 145.

² Ibid., l. c. 146.

the Eustachian tube is known to be a survival of the distal portion of this visceral cleft, cervical fistules in the position of the ear are often accompanied with malformation of the ear, particularly of the auricle.¹ In the judgment of C. F. Heusinger,² the diverticuli of the œsophagus are of the nature of incomplete cervical fistules.

For the literature of cervical fistulæ and related conditions, see F. M. Ascherson,³ M. Perls,⁴ J. Cusset,⁵ Neumann and Baumgarten, and W. W. Wagstaffe.⁶

Fig. 240.



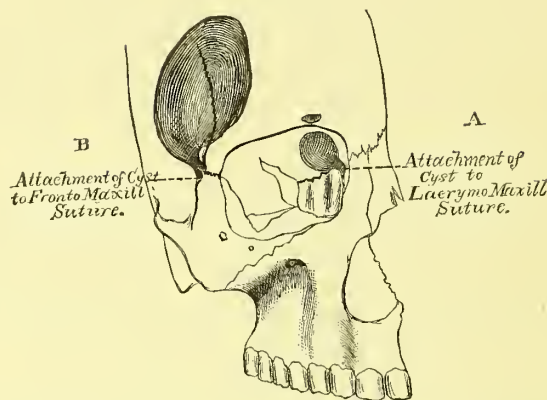
A profile sketch designed to illustrate by dotted lines the position of the branchial fissures. The letters answer to the spaces between the fissures. *a*, the space between parts developed from the *trabecula cranii*, and those of the first arch; *b*, the space between the upper and lower masses of the first arch; *c*, the space between the first and the second arch; *d*, the space between the second and the third arch; *e*, the space between the third and the fourth arch; *f*, the space below the third arch.

Fig. 240, from Cusset, will be useful for the location of the lines about which fistulæ and cystic formations may be looked for.

Fig. 241, from Wagstaffe, indicates the position of the last-named condition upon the suture of the facial region.

Not only may the visceral clefts and the spaces between the various parts of the plan of the face fail to unite, but *cysts* may form along the lines of union, and hyperplasia occur at the sutural lines of the bones in this region (Fig. 241). The presence of cysts in the neck should always be studied, as having origin along the lines of the interspaces, and it is probable that most accessions of tissue at sutural lines of bones, as in the

Fig. 241.



A figure of the front of the right facial region, designed to exhibit the points of attachments of congenital cysts of the cranial sutures.

median sutures of the face, notably those of the hard palate, are probably caused by the continuation of lines of growth, after the right and left parts of the plane have joined one to the other. It is in like manner probable that the existence of ivory exostosis at the root of the nose and in the associated parts may have its origin in a similar deep-lying cause.

On the Study of Correlated Parts.—From the facts of the normal development of the head, the face, the heart, ear, great vessels, and visceral arches, it is evident that a lesion in a single organ lodged within the general region embraced by these structures should be studied with reference to the entire set of organs of which it is a part.¹

A gross lesion in one part may be correlated with "anomalies," or with "variation" in another. Many minute variations escape detection, unless they are carefully sought for, and it is probable, that unusual proportion in parts so remote as the ossicles, the nasal chambers, the hyoid apparatus, the great cervical and upper intra-thoracic vessels may be found to correlate. The author has found congenital defects of speech to be associated with a shortened tongue, with absence of Shrapnell's membrane, with high arched palate, and nasal asymmetry.

It would appear that the ossicles of the ear are connected with the first and second visceral arches in ordinal arrangement with the series of cartilaginous rods within these arches. Thus the malleus is considered by Reichert to be the distal ossification in a series to which the remaining parts of the mandibular arch are

¹ J. Paget, *Med.-Chir. Trans.*, 1878, 39 (literature).

² *Virchow's Archiv*, xxix., 1864, 358, and xxxiii., 1865, 177 (copious literature).

³ *De Fistulis Colli Cong.*, Berlin, 1832.

⁴ *Lehrbuch der allgemein. Pathol.*, 290.

⁵ *Sur l'appareil branchial des Vertébrés*, Paris, 1877.

⁶ *Tr. Path. Soc. Lond.*, 1878, 194.

¹ See a case reported by Max Schultze (*Virch. Arch.*, xx., 1860, 378 (fig.)), in which the first and second visceral arches, symmetrical facial failure, and deformity of the incus and stapes of one side, existed in a single specimen.

homologous; and the anvil to be a part of equal value to it, in the hyoidean arch. Other writers assign the stapes also a place in the succeeding arch. Urbantschitsch, however, following Rathke and Valentin, believes that the malleus and incus develop within the same primitive bud or outgrowth, and are related, if with any, only with the mandibular arch.¹ However the question of the homologies of the ossicles may be settled, the claim that in their ranges of variation they correlate with the structures evolved from the visceral arches is in no way invalidated.

B) THE FORCES (LAWS OF MORPHOLOGY) UNDERLYING CONGENITAL MALFORMATION.

(1) GEMMATION.

By gemmation is meant a process of budding. Originally observed in plant-life, it has been found a constant phenomenon of the coral and coral-like animals,¹ and in the early stages of life of all animals. Buds, or gemmæ, are ordinarily projected from the sides of a trunk or the main body; but they may arise from the interior of an organ by a process of involution. The former variety of gemmation is illustrated in the growth of limbs, and the latter variety in the growth of hydatids, etc.

In some varieties of insect life, as in the plant louse (*Aphis*), the process of internal budding is seen. The ovary of the mature female is actively engaged in developing buds, which assume the form of the parent, and becoming detached, descend the oviduct, and escape in the shape of living offspring. It is an easy transition from this perfect example of physiological budding to the phenomena attending the formation of new tissues of a separate individual in the various tissues of more complex living bodies.

Gemmation may be assumed to take place for the most part in the early history of the embryo, and at a time before the appearance of nerve-centres, and nerves which control and modify the processes of nutrition. Buds arising in the plastic tissues of the early stage of general development can fuse with one another, or split up into numbers of coequal parts, according to the retardation or activity of the nutritive processes themselves.

Gemmation in many lower animals is an act which may continue through life, but in man and vertebrates generally it is confined to the embryonic period.

A familiar illustration of a bud in the development of the human embryo, is the stalk of the optic tract.

The pituitary body is a bud from the base of the brain. The origin of ducts of glands appended to the alimentary canal and the origin of the respiratory apparatus are also buds.

Buds may be assumed in general language to be synonymous with appendages. Thus limbs are the appendages of the trunk, and at the same time they are buds which spring from the trunk.

REMARKS.—In teratology numerous examples are presented by the operation of the law of gemmation. These may be divided into instances of external and of internal gemmation.

Internal Gemmation.	{ Dermoid Cyst.
	{ Fœtus by Inclusion.
External Gemmation.	{ Double Monster.
	{ Malformed Limbs.

Internal gemmation is illustrated in the dermoid cysts and in fœtus by inclusion.

Dermoid cyst. A number of cases are on record of tumors of the ovary, pituitary body or other parts, which were found to contain hair, teeth, mingled with horn, fat, and nerve-matter. They are thought to originate by a process of aberrant budding from those portions of the embryo in which they subsequently appear.¹

Fœtus by inclusion. Fœtus by inclusion (fœtus in fœtu) includes those growths which contain portions of a second fœtus or embryo, in such manner that within a fœtus, which is in other respects normal, portions of a second individual exist. The tumors are met with in the scrotum, the heart, the lower end of the trunk, and even in the head, and are found to contain more or less complete parts of an embryo. The masses probably represent one individual of double monstrosity, which by some means has become subordinated to its stronger associate, and at an early period of development has been embraced by it.

It is well to state that in the judgment of some writers the presence of a tumor of the kind above described does not necessitate the process of a monstrous growth; but that even complicated organs are capable of developing themselves in parts of the body where normally they do not exist.²

¹ See W. W. Wagstaffe, *Trans. Path. Soc. Lond.* xxix., 1878, 194.

² See Lebert, *Traité d'Anat. Path.*, i.; and Foulis, *Edin. Med. Journ.*, 1876, 839.—For the general literature of scrotal inclusion, see Verneuil, *Archiv. Gén. de Méd.*, 1855, i.-ii.; A. Jacob, *Dublin Hosp. Rep.*, iv., 1827, 571; Cruveilhier, *Path. Gén.* i. 370; W. H. Van Buren, *N. Y. Med. Journ.*, ii., 1866, 355; W. Macewen, *Glasgow Med. Journ.*, n. s., x., 1878, 433.

¹ Corals, hydroids.

External gemmation is illustrated in teratology in the formation of portions of a second individual, which are appended to the main body—double monsters—or in the explanation of supernumerary limbs or parts of limbs.

Double Monsters.—The appended portions of a second individual embrace tumors which do not ordinarily contain the central cavities of the body, and which account for those peripheral structures, congenital in character, which contain bone, nerve, fat, etc., of a second foetus.

A difference of degree alone exists between the class of tumors just denominated, and the presence of a foetus or portion of a foetus appended to the periphery of the body. In this way it is thought all forms of duplication of parts may be accounted for, whether the part be small, and not materially interfere with the usual outline, or be so pronounced as to give the expression of supernumerary limbs, portion of heads or trunks, or even an entire body, which is united to the main form by a narrow band or pedicle.

It is well to assume that each embryo possesses a separate yolk-sac or vitellus. If the tendency to duplication of parts extended from the blastoderm through the vitellus, two or more individuals could readily arise from a single ovum; a phase of generation commonly met with in many insects, in jelly-fishes, and related animals. Nothing similar to such division is, however, known to occur in vertebrate creatures. Twins are thought to arise from double conception, *i. e.*, the result of development in two separate eggs. Double monsters are often spoken of as "twins." The term "twin" is in this sense a convenient one only, and has no exact signification. A twin, strictly speaking, is one of two born at a birth. A double monster is a single individual, and as such arises from a single blastodermic membrane overlying a single vitellus.

Of all such united "twins," or nearly coequal duplicated persons, one individual is always the smaller. The larger frame will represent the main body, or, as the comparative anatomist would express it, the *parent-stock*.

Double monsters are of two kinds, those united along some part of the ventral aspects, and those united either by the crowns of the head or by the dorsal aspects. The normal head-fold, in place of forming a loop, uniting the medullary folds, may be incomplete, and permit the corresponding extremity of each fold to remain distinct.¹ Under some circum-

stances each fold will develop the parts of a perfect head, while the remaining portions will approximate and produce between them the dominating portions of a single individual. In this way a double-headed animal (*Diprosopus*, *Dicephalus*) may originate. Or the folds (separated by the lack of formation of the head-fold) may not tend to approximate, but remain distinct throughout their entire length, forming the basis of such forms of double monsters as *Pygopagus*.

In each of the foregoing examples, and in all intermediate forms, the vitellus remains unchanged. Hence, each portion of the egg, while presenting a double pair of parts, evolving the central nervous system and limbs, tends to have in common the organs of the chest and abdomen.

The malformations due to irregular formation of a single head-fold and adjacent parts will now be considered. Under the impress of some unknown trophic condition the head-fold or medullary folds develop atypically.

The head-fold may fail to unite the two medullary folds. Under this condition the latter do not approximate. A group of modifications based upon the above follow where the folds may approximate and join, and from the point or points at which they do so the parts of a single individual arise. Thus, if the folds remain distinct throughout their entire length, the embryos are united by their ventral surfaces only, and have more or less of the imperfectly divided abdominal and thoracic chambers in common. But at the points of embryonal contact of the medullary folds there exist, in addition to the great viscerol chamber, a single back-bone and central nervous system (*Thoracopagus*). In one of the most remarkable examples of double monster on record—the Siamese twins—the bond of union was much smaller than is ordinarily seen. But its position was strictly ventral, and contained hepatic tissue which seemed to unite the two livers. It follows that the proper position in which to study a specimen of united twins of this kind, is face to face, no matter what the position acquired during life may have been. One umbilical cord and placenta are present.

The head-fold may be normal, while the medullary folds fail to approximate, and each one develops a separate individual; the result is a single-headed two-bodied individual, forming the basis of such forms of double monster as *Pygopagus* (*Synencephalus*).

The medullary folds may be joined for the greater part of their length.

¹ This has been observed by Prof. S. F. Clarke in the *Ambystoma punctata*, a fresh-water salamander of the United States.

The folds may unite at the posterior ends only so as to exhibit the parts of the pelvis in common (Pygopagus).

Each of the above malformations has but a single umbilical cord.

As in the case of duplication of parts joined at the head an attempt at rotation is surmised to have occurred, so in the remaining varieties the relative positions of the two individuals can be explained by referring to the same tendency on the part of one or both embryos. The cause of the rotation would appear to be the contraction of the yolk-mass. This, of necessity, takes place toward the abdomen; and the contraction toward the abdominal space of a double embryonic mass, it is assumed, may change the position of the individuals. If the individuals are free in front, but fixed behind, the contraction causes irregular attempts at rotation to occur about the fixed point. Thus the anterior ends of the two trunks will either turn slightly away one from the other, and will place the heads in a position with the occiputs opposed, or they will so far diverge as to place themselves in the same line. If the embryos are united at the middle of the trunk the bodies remain variously fixed at the thorax and abdomen, being fixed at the thorax and abdomen in such wise as to cause the body to behave to the yolk as that of a single individual, and no material change of position of the free parts is practicable.

Malformed Limbs. The limbs may be looked upon as buds or peripheral outgrowths from the trunk. It follows that in an arrest of development the proximal portions will be rudimentary or absent, while the distal parts may be perfect. In this way stunted limbs with well-developed hands or feet projecting near the trunk are formed.

Excess or diminution of the number of toes or fingers is of relatively frequent occurrence. The excess is ordinarily an example of peripheral budding, while the diminution is a restriction due to some deep-lying cause affecting the tarsus or carpus of the individual. It may be held as an axiom that the carpus and tarsus determine the form and arrangement of the fingers and toes. Every description of a specimen of malformation of the hand or foot should be accompanied by an account of the dissection of the carpus or tarsus.

It has been already seen that supernumerary fingers or toes are, as a rule, examples of peripheral budding. They may be held to be such when they do not involve the carpus or tarsus; but when they involve these structures their origin may be traced

to some malformation of central instead of peripheral marginal elements. Thus, instead of the first or fifth finger being duplicated, the third may be increased in size—the supplemental third finger involving the carpus between the os magnum and the trapezium. It is evident from such a description that a mere superficial examination of the limbs would give no clue to the nature of the defect. Neglect of this simple precaution has led to much confusion in the description of defects of the hands and feet, notably in those instances where attempts have been made to explain malformations of excess by reversion to some partially obliterated ancestral tendency.¹

(2) PARTS WHICH ARE ARRANGED IN SERIAL ORDER.

The presence of a congenital defect in one portion of the vertebral column should induce the observer to make careful examinations of the entire vertebral series, including the bones of the cranium, as far forward as the body of the ethmoid bone. The central nervous system should also be inspected when this is practicable.

The manner in which the sternum develops suggests that an attempt is made in this bone for the several centres of ossification to be arranged in serial order, and in pairs. This arrangement is subject to much modification, but sufficient data exist to warrant the conclusion that a deformation in a portion of the sternum coexists with some minor variation or defect in another portion, and that the entire bone is more or less unusually formed.

The parts arising along the lines of the visceral arches are liable to malformations which embrace the entire development of the arch and often of related parts. (See p. 770.)

Exaggeration of the oral fissure (Maerostoma) is not a single malformation, but, as found by A. Thompson,² is associated with defects of the auricle, and atrophy of the lower jaw. In a case of cleft palate, recorded by E. Home,³ the lower jaw was abortive, and the external meatus narrowed.

The teeth are closely related structures whose variations conform to the rule that the malformations of serial homologous bodies are related one to another. (See p. 633.)

¹ See Otto, *Monstrorum sexcentorum descript.* Anat., tab. xx.—xxvi.; Musée Dupuytren; Ammon, *Die angeborenen Chir. krankheit. der Menschen*, Berlin, 1840, tab. xxii.; Meckel, *Archiv für Anat.*, xxxvi.

² *Edin. Monthly Journ.*, vii. 1874.

³ *Phil. Soc. Trans.*, lxxx., 1790, 175; also *Ibid.*, lxxxix., 1799, 189.

(3) IN ILLUSTRATION OF THE LAW OF REVERSION.

A malformation or variation which exhibits features recalling the normal arrangement in some lower animal is said to illustrate the law of *reversion*. In the human subject reversions are confined to the class of vertebrata, and most commonly suggest the disposition of parts in terrestrial mammals. Many examples have been cited in this book of such reversal variations.

It will be appreciated that a knowledge of comparative anatomy is essential to a correct interpretation of many unusual features in the anatomy of the body.—It is interesting to note that some variations in illustration of reversions (especially in the bones), are peculiar to the aged. While many of the instances of reversion are also those of gemination, the last instance noted is in marked contrast to such similarity. In the aged, varieties of reversion may be acquired after all active life processes are arrested or in a state of pathological change.

The presence of a large bone in the septum pectiniformis of the penis of many animals would lead the observer to seek for a rudiment of the bone in the septum as it exists in man. J. von Lenhossek¹ has described true osseous growths in the sheath of the cavernous bodies.

(4) IN ILLUSTRATION OF THE LAW OF SYMMETRY.

The disposition existing in the body for many parts to be arranged in pairs is capable of being modified. While geometrical symmetry does not exist between any of the organs of the body exceptional contrasts in volume and proportion naturally come within the scope of teratological studies. Under the operation of the law controlling the position of the organ may be conveniently placed all studies of *transposition of the viscera*.

One of the objects of symmetry is to secure periods of rest in organs of the same nature. Thus the right kidney is at rest when the left is active, as has been observed by Erichsen in studying cases of extrophy of the urinary bladder. It is of interest, according to O. Beumer,² to note the increased liability of subjects of single kidney to calculus of the pelvis of the kidney.

Rates of Growth as affecting the Origins and Behavior of Aberrant Structures. The rates at which the different portions of the embryo grow determine, of course, the order of the appearance of the several parts. When a structure appears at a period earlier than is usual, the rate of growth is said to be *accelerated*; or, per contra, when later than usual, to be *retarded*. Examples of acceleration are often spoken of as *precocity*. Instances of acceleration and retardation of a gross character are rare; the order of the rate of eruption of the teeth, and the union of epiphysis to the shafts of bones may be taken as illustrations. Acceleration and retardation may explain some of the variations of bloodvessels (see pp. 337, 395).

Retention illustrates a structure ordinarily transient in character, which remains as a part of the permanent structures of the embryo. Thus the *ductus arteriosus* remaining patulous at a time when, according to the average experience, it should become impervious, is an example of retention. Some of the characters of the skeleton of the adolescent sometimes will persist in adult life when they constitute the so-called retention of "juvenile character." In like manner the "infantile uterus" is sometimes found in the adult. Retention is also used to express the fact that a tooth which is retarded in development is *retained* entire within the structures of the jaws.

The general subjects of *aplasia* as illustrated in the study of dwarfs, and of *hyperplasia* as illustrated in the study of giants, come under the head of acceleration, retardation, and retention.

Structures retarded in development, or which remain in vestigial form beyond the period at which they are normal, are apt to yield to diseased action. Instances of this tendency are noted in the diseases of the remains of the thymus gland; in the diseases of the imperfectly developed or retarded wisdom-tooth; in the diseases of the structures entering into spina bifida and encephalocele; in the diseases of the imperfectly descended testis; and in cystic tumors originating in the hydatid of Morgagni. Since the prostate gland retains the rudiments of the terminal portions of the Müllerian ducts, as well as the associated matrix of the genital cord, the enlargement of this gland at times, when the dominating control of the sexual element in nutrition is being removed, may be in like manner explained by an aberrant acceleration occurring in a vestigial structure.

¹ Virchow's Archiv, lx., 1874, 1; Taf. 1. ² Ibid., 1878, 344.

ON MAKING POST-MORTEM EXAMINATIONS.

THE following rules for conducting post-mortem examinations will be found useful:—

The abdomen should be examined first. To effect this, a free incision should be made in the median line from the xiphoid cartilage to the pubis, care being at the same time exercised to shield the intestines from injury. In incipient decomposition the coils of small intestine lie closely apposed to the anterior abdominal wall, and will be liable to injury if the latter be not lifted from them, or a director slipped beneath the parietal peritoneum before the final section is effected. A transverse incision should next be made which will pass either immediately above or below the umbilicus. The four triangular flaps made by the above incisions may now be turned outward, the abdominal muscles divided from within outward, and the flaps turned over on the trunk. The abdominal contents, after being observed in their relations one with another, and with the trunk, may be examined in the following order:—

1. The peritoneum including the great omentum, the jejuno duodenal fossa, the pelvic folds, hernial protrusions, etc.

2. The small intestines (after the portal vein and its tributaries have been examined) may be secured at the beginning of the jejunum and at the end of the ileum by double ligatures (the gut being divided between them), and the mesentery boldly cut through. If no immediate interest attaches itself to the small intestine, the mass may be placed in water and examined at the close of the autopsy.

3. The genito-urinary apparatus should next be examined, extending in observation from above downward. The supra-renal capsule is here included for convenience.

4. The spleen, stomach, duodenum, pancreas, and liver next claim attention. These structures have intimate topographical and clinical relations. The colon being left in position is of importance, since many of the lesions of chronic disease, especially of the epigastric and hypochondriac organs, involve the

shape, size, position, and not infrequently even the integrity of the colon particularly at its transverse portion. The liver should be left to the last, because of the important relations it sustains to the Diaphragm. The Diaphragm is not to be disturbed, or the thorax opened, until the abdominal organs have been satisfactorily studied. This practice is advised, not because the mere removal of the upper abdominal organs would of necessity affect the arch of the Diaphragm, but because of the chances that it may do so. The almost inevitable dragging on the Diaphragm during the removal of the liver may cause the lungs to expand, and a false conclusion thus be arrived at respecting the ante-mortem condition of these organs, while a mere accidental puncture through this tense tendo-muscular septum will cause the entire structure to become flaccid, and the condition of the base of the pleural cavities, and of the lower part of the pericardium as it existed during life to be irrevocably destroyed.

In removing the liver from its bed the lateral ligaments should be first divided, the hand (with palm down) should next be thrust between the Diaphragm and the liver, and the former thus peeled from the latter. The organ should be isolated from all topographical relations, and held by the organic only, namely those found in the lesser omentum. This important band should not be divided until after the duodenum and pancreas have been studied. In the above description it is noticeable that the knife is used only in dividing the lateral ligaments and the lesser omentum; all other connections can be removed with the fingers. The Spigelian lobe is thus saved intact, the free use of the knife from above downward often resulting in the mutilation of this lobe.

For the simple examination of the stomach a longitudinal section of the anterior wall will suffice. The organ should be removed by separating the Diaphragm from the oesophagus and dividing the latter as high up as can be done without destroying the Diaphragm. The lower end should be preserved intact by dividing the ascending portion of the duodenum.

This procedure preserves the lesser curvature of the stomach and the exact position of the pylorus.

The duodenum and pancreas can be examined together. The first-named may be opened in continuity with the stomach by an extension of the same incision. Should it be deemed advisable to remove the organ, such removal is to be reserved until after the examination of the spleen is finished. The pancreas and the duodenum are in part retro-peritoneal, and their relations with the kidneys, thoracic duct, sympathetic ganglia, and bloodvessels should be sought for.

The spleen is best removed by seizing it with the hand, and drawing the vascular pedicle (holding it to the cardiac end of the stomach) until such structure becomes tense, when it should be divided by the knife or scissors.

The pancreas and duodenum still being in position, and the liver held to its physiological relations by the lesser omentum, and its contents remaining intact, the condition of the biliary and the pancreatic ducts should be observed, as well as that of the portal vein. Lesions of the hepatic or other branches of the coeliac axis of vessels are so rare that the observer may be excused examining this condition in other than in obscure disease, referable to its branches.

The Biliary Ducts. The examination of these is of great importance. In the language of Virchow,¹ "the papilla of the ducts of the liver and pancreas should be examined and its contents gently pressed out; then by pressing on the gall-bladder, we should determine the presence or absence of obstacles to the flow of bile; and, lastly, the ductus communis choledochus should be slit up." "It is quite useless to pass a probe along the gall-duct, for our being able to introduce a probe into the orifice is no evidence whatever that the intestinal (mural) portion was pervious during life."

A final word of warning must be given before the abdomen is left. If the centre of attraction is the autopsy centre about the heart, or of a condition of which the heart and liver are or have been important agents, the above account of the examination should be so far modified as to enable the operator to retain the liver in position until the thorax has been opened and the heart examined. It is very evident that the removal of the liver will, by severing the hepatic vein, cause the inferior cava and possibly the right side of the heart and superior cava to empty a portion of their contents into the abdominal cavity, and the

exactness of a subsequent observation on these parts thus be lost. It is true this misadventure can be prevented by ligation of the hepatic veins before the ablation of the organ. But such an operation is tedious.

The order of examination of the abdomen, as recommended by Virchow,¹ is as follows:—

- (1) The omentum.
- (2) The spleen.
- (3) The left kidney, supra-renal capsule, and ureter.
- (4) The right kidney, supra-renal capsule, and ureter.
- (5) The bladder, prostate gland, vesiculæ seminales, and urethra.
- (6) (a) The testicles, spermatic cord, and penis.
(b) Vagina, uterus, Fallopian tubes, and ovaries, etc.
- (7) The rectum.
- (8) The duodenum and intestinal portion of the ductus communis choledochus.
- (9) The stomach.
- (10) The hepato-duodenal ligament, gall-ducts, vena portæ, gall-bladder, and liver.
- (11) The pancreas and semilunar ganglia.
- (12) The mesentery, with its glands, vessels, etc.
- (13) The small and large intestines.
- (14) The retro-peritoneal lymphatic glands, receptaculum chyli, aorta, and vena cava inferior.

In the event of an abdominal incision being impracticable, it is well to know that not only the pelvic organs, but all the abdominal organs, can be removed *per vaginam*. The liver alone would have to be divided with scissors before removal.

Thorax. Virchow¹ has given the general direction that, after the abdomen is opened and the general relations of the organs made out, the thoracic organs should be next studied *in situ*. In a word, all the *relations* of the organs in both great visceral chambers should be ascertained before proceeding to the dissection of either. If ordinary care be taken concerning the wounding of the Diaphragm, or the escaping of blood from the larger veins, the thoracic relations need not be of necessity disturbed. The preservation of the arch of the Diaphragm—its height—its relations to the liver and the chest-wall, however, *must* be made out before the thorax is opened. No case of hepatic abscess, peri-hepatitis, diaphragmitis, pleurisy, pericarditis, ascites, peritonitis, not to mention wounds and fractures of the ribs, can be satisfactorily studied un-

¹ R. Virchow, Method of Performing Post-mortem Examinations. Trans. by T. P. Smith.

¹ L. c., p. 22.

less the post-mortem examination of the Diaphragm be made accurately before its points of insertion, or the pressure to which it had been subject during life, had been disturbed.

To open the chest an incision should be made, extending from the centre of the inter-clavicular space downward to be continuous with the abdominal incision. The skin is quickly turned to either side by long sweeping cuts of the knife, the edge of which should keep close to the chest-wall, and expose the ribs at every stroke; the cleaner the exposure, the easier becomes the work of preparation for opening the chest-wall. Upon approaching the false ribs, the upper flaps, already made from the abdomen, should be held up, and the knife made to divide the slips of origin of the oblique muscles, so as to leave the lower ribs as clean as the upper. If the subject be young, the costal cartilages may be divided by a stout knife or costatome, immediately to the inner side of the sternal ends of the ribs, and a transverse section joining the longitudinal ones, about the line of the middle of the second costal cartilage. The last-named line will sever the manubrio-gladiolar junction. If, however, the parts mentioned are ossified, the saw must follow the lines of the incisions as given. Ordinarily, the saw is used for dividing the cartilages, and the knife for dividing the sterno-clavicular articulation.

The procedure of severing the attachment between the clavicle and the sternum is best effected as follows: Divide the first costal cartilage by an oblique incision from below upward and inward toward the under surface of the joint. This allows the knife to enter the joint at the lower edge of the sternal facet. Care should be taken to avoid opening the innominate vein. In opening the joint from above, more especially if the first costal cartilage be not first divided, the vein is often entered by the incautious use of the knife. The escape of blood into the pleural cavities is always unfortunate. The pleuræ become smeared with blood, disguising their true appearance, and the serous fluid is lost.—Sawing through bone (either of rib or sternum) should be avoided when possible. If the section with the saw is compulsory, the edges should be covered with towelling to protect the hands of the operator.

Littlejohn¹ has advised that, before the Diaphragm is raised, after the costal cartilage and diaphragmatic attachments have been divided, "the hand should be passed up into the anterior mediastinum, breaking

up the connective tissue, and exposing to the touch the organs as high as the root of the neck." This procedure frequently enables the operator at once to discover the probable cause of death. Any tumor, whether aneurismal or otherwise, is readily detected, and some general idea obtained as to the size of the heart and of the condition of the lungs. Nothing can be more embarrassing than to mutilate an aneurismal sac in removing the sternum; whereas, the existence of a swelling in the neighborhood of the aorta having been ascertained, greater care is exercised in separating the sternum, and the diseased structures are exposed in an uninjured condition.

The organs should now be described *in situ*.

The Lungs. It is not necessary to remove the lungs in order to examine them. If the object of the examination be to ascertain the general appearance of the parenchyma and pleura, the root of the lung need not be disturbed, but using it as a fixed point, the lung can be raised from its position and (by inserting a towel or large sponge in the pleural cavity) the organ can be thrown up above the plane of the body, placed thus in a good light, while such section or measurement is made as may be thought necessary.

The Heart. The heart, from the delicacy of its mechanism, the complexity of its several parts, and the great importance frequently attached to its examination after death, is to be studied with great care, and the necessary section to explore its interior is to be made with precision.

After the pericardium is opened, the serum therein contained should be removed by a syringe and measured. The same instrument should be used in withdrawing any fluid from the body, rather than a sponge, which is of necessity a much less accurate aid. Each chamber of the heart should be opened separately, but in such manner as to cause the least amount of injury to the valves, septa, and the orifices of the veins and arteries.

The incisions proposed by Virchow (l. c., p. 36) are as follows:—

For Right Auricle, beginning half way between the planes of entrance of the venæ cavæ, and ending just in front of the base.

For Right Ventricle, beginning close to the base and carried nearly, but not quite, to apex; if carried too far toward the apex, the septæ will be injured.

For Left Auricle beginning at the left superior pulmonary vein, and ending in like manner just in front of the base, which is usually indicated by the very prominent coronary vein. The coronary veins should be carefully avoided.

¹ Edinburgh Med. Journ., 1876, 1113.

For the Left Ventricle, beginning behind the base, and ending short of the apex.

In making the incisions on the right side, the heart is held in the left hand, and rotated toward the left, so as to bring the right lateral border uppermost. In making those of the left side, the heart is seized toward the apex, drawn inward and to the left, while the thick close-set lateral wall is caused to bulge out by gentle pressure.

After the blood has been removed from the cavities and examined, the heart is severed at its base by dividing the great vessels, a fair distance from the heart, and the pulmonary arteries and veins at the roots of the lungs.

After removal, the capacity of the ventricles and the accuracy of closure are approximately determined by pouring water downward into the auricles and great vessels.

This is a reasonably accurate test for the semilunar valves, since they are normally closed by the recoils of the blood sent into the pulmonary artery or aorta, back against the cups of the valves. For the auriculo-ventricular valves, however, it is necessarily imperfect, since the force of the water does not imitate the normal act of closure, which is intricate, and cannot be performed apart from the living organism.

The sections for the study of the valves are selected by following the lines of the natural passage of the blood. Incisions should be made with care through the anterior wall of the right ventricle to avoid injuring the anterior papillary muscle, the moderator band, and the small septal leaflet of the tricuspid valve.

In opening the left auriculo-ventricular valve, it should be remembered how distinct its axis is as compared to that of the right side, and that one of the leaflets of the valve lies close to the septum, and may be injured by incautious adherence to a line too near that structure. By inserting the finger from the right ventricle upward along the pulmonary artery or from the left ventricle along the aorta until the anterior of the three corpora aurantii is felt, a pair of blunt-pointed scissors may be passed along the finger and the valve be divided without liability of injuring the leaflets.

In the event of disease involving the entire respiratory tract, or when the lesion is one requiring careful dissection of the parts at the base of the heart or the root of the lung, the best plan of procedure, after the organs have been carefully studied in position, and surrounding circumstances favoring, is to remove the thoracic viscera *en masse* inclusive of the trachea,

larynx, and hyoid bone. This can be easily effected by making a vertical incision through the skin along the median line of the neck (the sternum having been previously removed), and the soft parts roughly dissected to the sides. A transverse incision is now made above the hyoid bone downward to the vertebral column. The trachea is next seized with the left hand and pulled downward toward the thorax, the knife being held in the right hand in order to divide the vessels at the root of the neck as they become tense under the downward strain. Below the position of these vessels no obstruction exists to the easy separation of the aorta and other parts from the front of the vertebral column, and the evulsion of the entire contents of the thorax over the abdomen is soon accomplished. The removal of the various points of attachment is soon accomplished, and the organs can be placed aside in a preservative fluid for detailed study.

In rupture of the aorta into the pericardium, when the orifice is so small as to escape notice, it is recommended by Littlejohn¹ to incise the left ventricle and pass the forefinger of the right hand into the aorta. "As the ruptured orifice is generally situated anteriorly, by simply pressing the finger against the wall of the vessel the slightest depression is detected, and then, on closer examination, the minute rupture is detected. Should any doubt remain, the aorta may be compressed at the arch, and some water injected upwards from the ventricle, when a tiny jet will quickly determine the site of the aperture."

The Brain. This is examined after the abdomen and thorax. If it be examined first, the escape of venous blood from the sinuses will drain venous blood (particularly if the head is allowed to remain pendent from the edge of the dissecting table, as is often the case) from the *venæ cavæ* and heart. It is evident, however, that the reverse of this proposition is true, and if in the judgment of the operator the condition of the parts in the skull be of greater importance than those of the trunkal cavities, there can be nothing to oppose, but, on the contrary, everything to favor the examination of the head before opening either the abdomen or the thorax.

To examine and remove the brain the sections must be as follows: With a sharp knife the operator should penetrate the scalp over the ear, and, keeping the point upward, cut the scalp from within outward, while the section is made toward the vertex, and from that region downward to the ear of the opposite side.

¹ Edinburgh Med. Journ., 1876, 1116.

In this manner the scalp is divided from ear to ear (the hair being but little injured), and forms two flaps which can be easily retracted to expose the skull. The skull should now be sawed in such manner as to make a circular section round the head, a little above the ear. To avoid the inconvenience of using the saw at the occiput, upon which point the weight of the skull rests, some physicians confine the circular incision to the frontal and temporal regions, and join its ends by an oblique rim extending upward and backward between the occipital protuberance and the lambdoidal suture. There can be no objection to the latter section where removal of the brain is alone intended. It has, indeed, the advantage of holding the skullcap in better position than when the circular incision is employed. The incision first named is to be preferred when the brain is to be studied *in situ*, and the skull preserved. Neither should there be any difficulty in readjusting the round-based skullcap. Hard wooden pegs, or, what is perhaps better, iron brads, can be driven in the diploë of the occipital and lateral parts of the frontal bone, and the free projecting ends sharpened to a point. The skullcap can be fitted thereto by placing the ends of the pegs or brads in the diploë, and firmly forcing the skullcap downward. Dr. Chas. K. Mills¹ recommends, in making the section which will expose the brain-case, that the Temporal muscle-fibres be left on the skull-cap, as a few stitches through the divided ends of the muscle assist materially in holding the skull-cap in position. The saw need not pass entirely through the skull. A few strokes of the hammer on the chisel of the post-mortem set will suffice to sever the inner brittle plate. It is, perhaps, unnecessary to point out the fact that the skull is thinner at the temporal region than elsewhere, and is least thin at the occiput. The incautious operator may injure the brain at the former point long before he has reached the inner plate at the latter. The dura mater may be cut through along the line of the section made by the saw, and thus, should it be adherent to the skullcap, may be removed therewith, the scissors being used to divide the points of union with the great longitudinal falx. It has been advised, especially in the autopsies of children, to saw through both bone and brain together, in cases where the study of the form of the brain is a matter of little importance. After the skullcap and dura mater have been removed, and the pia mater exposed, the condition of the bloodvessels

should be studied with care, and both sides of the pia mater examined. The base should not be disturbed until the condition of the superficies, corpus callosum, and the quantity of fluid in the ventricles have been ascertained. Removal of the brain under the most favorable circumstances lacerates the already softened structures. Even in the normal brain, the falling outward of the cerebral hemispheres (now no longer supported by the sides of the skull and falx) will sever the middle commissure of the third ventricle. The brain, while yet in position, will permit the lateral ventricles being opened by a vertical section made a half inch to the outer side of the great longitudinal fissure downward to the lateral ventricle, which being thus opened, a syringe furnished with a long nozzle may be used to withdraw the fluid.

In suspected fracture of the cranium, special care must be taken to avoid the blows of the mallet in any way complicating the lesion. The same writer advises that the saw should never pass further than fairly into the diploë, and whenever practicable the so-called inner plate be left intact. Instead of the mallet and chisel, he recommends that the chisel alone be used. "A stout piece of steel is loosely fitted by an aperture to the chisel edge, and, gravitating by its weight, is arrested at the shoulder of the instrument, thus forming a cross where the two portions are adjusted. By sawing deeply over the frontal sinus, the sharp edge of the chisel is easily inserted; and by simply turning the chisel round, the internal plate at once gives way with a slight crack, and the skullcap is felt to be detached."

The interior of the calvarium should be carefully examined for evidence of fracture.

In removing the brain the anterior portion of the cerebrum should be gently raised and all the cranial nerves be severed at their points of exit through the floor of the brain-case. The tentorium is next slit from side to side, and the medulla oblongata severed from the spinal cord by making an oblique cut with a long knife as far down in the vertebral canal as is possible. The pituitary body, by a *tour de force*, can be removed with the brain, the pedicle remaining intact. Ordinarily, however, this body is left in the pituitary fossa. The brain when removed should be placed base upward in a shallow vessel with curved sides, such as a tin wash-basin, to avoid the falling outward of the hemispheres. Perhaps the best plan is to invert the brain in the skullcap, and place the latter top downward in a towel folded loosely in the basin. Prof. Burt G. Wilder recommends dividing the brain longitudinally in the median line, and placing the

¹ Phila. Med. Times, 1880, vol. x. 365.

median surfaces downward upon the bottom of a flat dish. The subsequent examination of the brain must be conducted according to the immediate object in view. Indiscriminate slicing of the organ is to be avoided. If the intention is to determine the general condition of the parts without reference to any minute study of the texture of the organ, the examination may begin by exposing the lateral ventricles. The incisions made as above recommended to expose these cavities with a view of collecting the fluid, manifestly cannot be made to any advantage after the brain has been removed from the head. Conceding, therefore,¹ that such incisions have already been made, a narrow knife is next passed through the foramen of Monro, and the corpus callosum and the fornix divided transversely. These parts are turned back in order to display the cavity of the third ventricle. The horns of the lateral ventricle can be slit up by an incision extending along their entire lengths. The velum body and the pineal interpositum are next examined, the greatest care being required—owing to the intimate association existing between it and the fibres of the velum—to preserve the pineal body uninjured. A director is next passed along the communicating passage between the third and fourth ventricles, and the superimposed tissue divided. The cerebrum is next usually sliced from within outwards in crude imitation of the compartments of an orange, viz., each section being narrow toward the lateral ventricle, but wide toward the outer surface. The object of such treatment is to examine carefully for alterations of a morbid character, and to permit the different compartments or divisions to be examined at will and returned to their natural relations. This method further aids the preservation of the tissues by permitting the selected fluid to permeate through the entire thickness of the cerebrum. To display the relations of the nuclei of the striated body one to another and to the cortex horizontal sections may be made in the manner used to demonstrate the arbitrary planes of the cerebrum, viz., the lesser and greater oral sections. In the language of Dr. Mills (l. c.) the cerebrum may be divided, according to the method of M. Pitres (see p. 508), as follows:—

“The first incision is made through the præ-frontal region, the second, through the bases of the three frontal convolutions, the third, through the ascending frontal convolution, the fourth, through the ascending parietal convolution, the fifth, through the superior and inferior parietal lobules, and the sixth, through the occipital lobe. The incisions should be made in

each hemisphere from within outwards nearly to the convolutions.

“Instead of the vertico-transverse, the vertico-longitudinal section may be used. In this method beginning at the cerebral peduncles, smooth incisions long and deep enough to expose all the parts to within a few lines of the convolutions of the base should be carried through both optic thalami and corpora striata and out into the hemispheres, a few extra sections being made in the white matter above the level of the ventricles.

“It may sometimes be desirable to examine the interior of the cerebrum from the base, which can be readily done, particularly if a fair knowledge on the part of the operator is possessed of the relations of the fissures and convolutions of the surface to internal eminences and cavities.”

The Spinal Cord. The spinal cord can be removed with advantage as follows: After severing the laminae of the vertebrae by the saw or with pliers, sever the dura mater and the cord at the level of the foramen magnum. The membranes and the cord at the plane of this section are then lifted together from the vertebral canal, the nerves, and the filum terminale being successively divided, the entire cord with the membranes are removed. The dura mater and the pia mater may then be slit and the surface of the cord inspected; subsequently the specimen may be divided in sections of convenient length and immersed in an appropriate preservative fluid.

The Ear and Nasal Chambers. To the student of nasal and aural diseases it often becomes desirable to remove the nasal chambers and the ears for special study. Schalle¹ has written an elaborate paper descriptive of a process original with himself which is undoubtedly the best that has yet been offered to effect this object. The essential feature of his method is the removal of all the parts of interest, which cannot be inspected upon the undissected body, and the securing of such without mutilation of the features, or the making of unsightly seams.

After removal of the skullcap and the brain, as already described, a trifoil-like figure is traced upon the floor of the brain-case so as to include in the anterior leaflet the anterior part of the basilar process of the occipital bone, the body and basal portions of the greater and lesser wings of the sphenoid bone, and the inner halves of the orbital plates of the frontal

¹ Virchow's Archiv, vol. 71, 1877, 206, Pl. ix. The plate displays the line to be followed by the saw, a figure of the parts removed, and of the instruments employed.

bone (inclusive of the cribriform plate of the ethmoid), while the petrous portions of the temporal bone lie in the lateral leaflets. The junction of the anterior leaflet and the lateral leaflets is secured at a point answering to the bottom of the glenoid fossa, which in the brain-case answers to a point at the base of the petrosal eminence at the lateral half of the middle cerebral fossa. It is to be understood from the onset that a section of the skull the shape and size of the trifoil figure is to be removed by vertical section. The essential feature of the procedure is to insert a narrow saw-blade of a bow-saw through an opening made through the middle cerebral fossa at the point indicated, and the section made by sawing out vertically the pattern of the trifoil.

The plan being thus understood, Schalle begins the dissection of the parts outside the brain-case as follows:—

An incision is made with a stout scalpel over both clavicles, from one acromial process to the other. The head and neck are next made to fall by a shoulder-block being thrust beneath the scapula, and the incision continued upward, along one side of the neck to an inch and a half above and behind the external auditory meatus, and is here made continuous with the transverse incision across the vertex already made for removal of the skullcap. It now descends on the opposite side of the neck, and meets the acromial end of the first trans-clavicular incision. This long and bold cut can be well covered subsequently by the clothing, and permits of free manipulation of parts lying between the limits of the incision, both in front and behind.

The anterior flap is turned down over the face to the brows, and laterally, by free incision through the cartilaginous external auditory meatus, to over the cheeks. Next the anterior flap is raised from the clavicles to the lower jaw. The structures of the supra-hyoid region, viz., the Genio hyoid, Mylo-hyoid, Hyoglossus, Genio-glossus, and D'gastric muscles, the facial arteries, etc., are divided, and the tongue drawn down and out of the mouth upon the neck. The palato-glossal and pharyngo-glossal connections are next divided, the pharynx severed about on the level of the aperture of the larynx, and the entire hyoid apparatus with the tongue pulled toward the sternum, thus leaving a free space for manipulation upon the under part of the skull. The Pterygoid muscles are now separated from the lower jaw, the temporo-maxillary articulation opened from within, and the lower jaw drawn forward, so as to rest upon the articular eminence in advance of the glenoid fossa.

The molar teeth in the upper jaw are now extracted to avoid the resistance they would offer to the action of the saw.

The posterior wall of the pharynx is next removed from in front of the vertebral column, and as far as possible from the roof of the pharynx. All the space needed is secured. It is now necessary to fix the lower jaw in its forward position at the chin, and to steady the skull while the bottom of the glenoid fossa is perforated to permit the use of the saw, which is made to perform a circuit, cutting out in the shape of a trifoil-cylinder the cavity of the nose and both petrous portions of the temporal bone. The saw should pass between the crista galli and the foramen cæcum in front, close to the squamous portion of the temporal bone at the sides and about midway between the foramen magnum and the occipito-sphenoidal junction, behind.

When the section is complete it can be removed from above by gentle pressure on the hard palate. The specimen will not include the anterior half of the superior maxilla, the anterior ethmoidal cells, the anterior part of the inferior turbinate bone, the interior of the external nose, nor the outer posterior part of the mastoid process. These should, therefore, be carefully inspected in the cadaver before closing the parts.

To effect the latter the lower jaw must be readjusted to the portion of the glenoid fossa yet remaining in position, the tongue and hyoid apparatus replaced. The brain-case is filled with some light absorbent material, such as sawdust or oakum, and the remains of the eyeballs pushed outwards—since the section has, of necessity, included part of the orbital contents. The skullcap is restored in the ordinary way, and the skin-flaps readjusted. This manipulation appears at first sight laborious, and would doubtless prove so to a tyro. To one accustomed to the use of instruments no great degree of difficulty need be anticipated.

It is likely that the use of the dental engine, in lieu of the bow-saw, would greatly facilitate making the section.

Foulis¹ advocates an examination of the middle ear by splitting the petrous portion of the temporal bone with a chisel along a line parallel to the squamous plate, directly to the outer slope of the eminence caused by the superior semicircular canal. The tympanum is opened by this procedure, as well as the mastoid cells, while the stapes is usually separated from the incus. Should a particular examination of

¹ British Med. Journ., April 24, 1880.

the inner ear be desired, the loose bits of the "petrous bone" might be again divided in various directions according to the demands of the case. This method, while confessedly crude, may be of some value where circumstances do not permit of more systematic exploration.

The Eye. The removal of the eye, when it is not deemed important to extirpate the entire globe, can be easily accomplished by breaking through the brittle orbital plate, and dividing the eyeball transversely immediately behind the corneo-scleral junction. The eyeball, thus mutilated, is then lifted from its bed,

the insertion of the peri-ocular muscles divided, and the nerve severed.

The Bones. It often becomes necessary to saw the long bones longitudinally. The selected bone should be fixed in a vise, and the section made by the ordinary saw of the post-mortem case. If a gig-saw be available, especially one run by steam-power, the operator will save much time and trouble by securing the assistance of a workman skilled in the use of such a machine. The section by this means is made with great celerity and precision in any desired direction.

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(3) IN ILLUSTRATION OF THE LAW OF REVERSION.

A malformation or variation which exhibits features recalling the normal arrangement in some lower animal is said to illustrate the law of *reversion*. In the human subject reversions are confined to the class of vertebrata, and most commonly suggest the disposition of parts in terrestrial mammals. Many examples have been cited in this book of such reversional variations.

It will be appreciated that a knowledge of comparative anatomy is essential to a correct interpretation of many unusual features in the anatomy of the body.—It is interesting to note that some variations in illustration of reversions (especially in the bones), are peculiar to the aged. While many of the instances of reversion are also those of gemination, the last instance noted is in marked contrast to such similarity. In the aged, varieties of reversion may be acquired after all active life processes are arrested or in a state of pathological change.

The presence of a large bone in the septum pectiniformis of the penis of many animals would lead the observer to seek for a rudiment of the bone in the septum as it exists in man. J. von Lenhossek¹ has described true osseous growths in the sheath of the cavernous bodies.

(4) IN ILLUSTRATION OF THE LAW OF SYMMETRY.

The disposition existing in the body for many parts to be arranged in pairs is capable of being modified. While geometrical symmetry does not exist between any of the organs of the body exceptional contrasts in volume and proportion naturally come within the scope of teratological studies. Under the operation of the law controlling the position of the organ may be conveniently placed all studies of *transposition of the viscera*.

One of the objects of symmetry is to secure periods of rest in organs of the same nature. Thus the right kidney is at rest when the left is active, as has been observed by Erichsen in studying cases of extrophy of the urinary bladder. It is of interest, according to O. Beumer,² to note the increased liability of subjects of single kidney to calculus of the pelvis of the kidney.

Rates of Growth as affecting the Origins and Behavior of Aberrant Structures. The rates at which the different portions of the embryo grow determine, of course, the order of the appearance of the several parts. When a structure appears at a period earlier than is usual, the rate of growth is said to be *accelerated*; or, per contra, when later than usual, to be *retarded*. Examples of acceleration are often spoken of as *precocity*. Instances of acceleration and retardation of a gross character are rare; the order of the rate of eruption of the teeth, and the union of epiphysis to the shafts of bones may be taken as illustrations. Acceleration and retardation may explain some of the variations of bloodvessels (see pp. 337, 395).

Retention illustrates a structure ordinarily transient in character, which remains as a part of the permanent structures of the embryo. Thus the *ductus arteriosus* remaining patulous at a time when, according to the average experience, it should become impervious, is an example of retention. Some of the characters of the skeleton of the adolescent sometimes will persist in adult life when they constitute the so-called retention of "juvenile character." In like manner the "infantile uterus" is sometimes found in the adult. Retention is also used to express the fact that a tooth which is retarded in development is *retained* entire within the structures of the jaws.

The general subjects of *aplasia* as illustrated in the study of dwarfs, and of *hyperplasia* as illustrated in the study of giants, come under the head of acceleration, retardation, and retention.

Structures retarded in development, or which remain in vestigial form beyond the period at which they are normal, are apt to yield to diseased action. Instances of this tendency are noted in the diseases of the remains of the thymus gland; in the diseases of the imperfectly developed or retarded wisdom-tooth; in the diseases of the structures entering into spina bifida and encephalocoele; in the diseases of the imperfectly descended testis; and in cystic tumors originating in the hydatid of Morgagni. Since the prostate gland retains the rudiments of the terminal portions of the Müllerian ducts, as well as the associated matrix of the genital cord, the enlargement of this gland at times, when the dominating control of the sexual element in nutrition is being removed, may be in like manner explained by an aberrant acceleration occurring in a vestigial structure.

¹ Virchow's Archiv, lx., 1874, 1; Taf. 1.

² Ibid., 1878, 344.

ON MAKING POST-MORTEM EXAMINATIONS.

THE following rules for conducting post-mortem examinations will be found useful:—

The abdomen should be examined first. To effect this, a free incision should be made in the median line from the xiphoid cartilage to the pubis, care being at the same time exercised to shield the intestines from injury. In incipient decomposition the coils of small intestine lie closely apposed to the anterior abdominal wall, and will be liable to injury if the latter be not lifted from them, or a director slipped beneath the parietal peritoneum before the final section is effected. A transverse incision should next be made which will pass either immediately above or below the umbilicus. The four triangular flaps made by the above incisions may now be turned outward, the abdominal muscles divided from within outward, and the flaps turned over on the trunk. The abdominal contents, after being observed in their relations one with another, and with the trunk, may be examined in the following order:—

1. The peritoneum including the great omentum, the jejuno duodenal fossa, the pelvic folds, hernial protrusions, etc.

2. The small intestines (after the portal vein and its tributaries have been examined) may be secured at the beginning of the jejunum and at the end of the ileum by double ligatures (the gut being divided between them), and the mesentery boldly cut through. If no immediate interest attaches itself to the small intestine, the mass may be placed in water and examined at the close of the autopsy.

3. The genito-urinary apparatus should next be examined, extending in observation from above downward. The supra-renal capsule is here included for convenience.

4. The spleen, stomach, duodenum, pancreas, and liver next claim attention. These structures have intimate topographical and clinical relations. The colon being left in position is of importance, since many of the lesions of chronic disease, especially of the epigastric and hypochondriac organs, involve the

shape, size, position, and not infrequently even the integrity of the colon particularly at its transverse portion. The liver should be left to the last, because of the important relations it sustains to the Diaphragm. The Diaphragm is not to be disturbed, or the thorax opened, until the abdominal organs have been satisfactorily studied. This practice is advised, not because the mere removal of the upper abdominal organs would of necessity affect the arch of the Diaphragm, but because of the chances that it may do so. The almost inevitable dragging on the Diaphragm during the removal of the liver may cause the lungs to expand, and a false conclusion thus be arrived at respecting the ante-mortem condition of these organs, while a mere accidental puncture through this tense tendo-muscular septum will cause the entire structure to become flaccid, and the condition of the base of the pleural cavities, and of the lower part of the pericardium as it existed during life to be irrevocably destroyed.

In removing the liver from its bed the lateral ligaments should be first divided, the hand (with palm down) should next be thrust between the Diaphragm and the liver, and the former thus peeled from the latter. The organ should be isolated from all topographical relations, and held by the organic only, namely those found in the lesser omentum. This important band should not be divided until after the duodenum and pancreas have been studied. In the above description it is noticeable that the knife is used only in dividing the lateral ligaments and the lesser omentum; all other connections can be removed with the fingers. The Spigelian lobe is thus saved intact, the free use of the knife from above downward often resulting in the mutilation of this lobe.

For the simple examination of the stomach a longitudinal section of the anterior wall will suffice. The organ should be removed by separating the Diaphragm from the œsophagus and dividing the latter as high up as can be done without destroying the Diaphragm. The lower end should be preserved intact by dividing the ascending portion of the duodenum.

This procedure preserves the lesser curvature of the stomach and the exact position of the pylorus.

The duodenum and pancreas can be examined together. The first-named may be opened in continuity with the stomach by an extension of the same incision. Should it be deemed advisable to remove the organ, such removal is to be reserved until after the examination of the spleen is finished. The pancreas and the duodenum are in part retro-peritoneal, and their relations with the kidneys, thoracic duct, sympathetic ganglia, and bloodvessels should be sought for.

The spleen is best removed by seizing it with the hand, and drawing the vascular pedicle (holding it to the cardiac end of the stomach) until such structure becomes tense, when it should be divided by the knife or scissors.

The pancreas and duodenum still being in position, and the liver held to its physiological relations by the lesser omentum, and its contents remaining intact, the condition of the biliary and the pancreatic ducts should be observed, as well as that of the portal vein. Lesions of the hepatic or other branches of the celiac axis of vessels are so rare that the observer may be excused examining this condition in other than in obscure disease, referable to its branches.

The Biliary Ducts. The examination of these is of great importance. In the language of Virchow,¹ "the papilla of the ducts of the liver and pancreas should be examined and its contents gently pressed out; then by pressing on the gall-bladder, we should determine the presence or absence of obstacles to the flow of bile; and, lastly, the ductus communis choledochus should be slit up." "It is quite useless to pass a probe along the gall-duct, for our being able to introduce a probe into the orifice is no evidence whatever that the intestinal (mural) portion was pervious during life."

A final word of warning must be given before the abdomen is left. If the centre of attraction is the autopsy centre about the heart, or of a condition of which the heart and liver are or have been important agents, the above account of the examination should be so far modified as to enable the operator to retain the liver in position until the thorax has been opened and the heart examined. It is very evident that the removal of the liver will, by severing the hepatic vein, cause the inferior cava and possibly the right side of the heart and superior cava to empty a portion of their contents into the abdominal cavity, and the

exactness of a subsequent observation on these parts thus be lost. It is true this misadventure can be prevented by ligation of the hepatic veins before the ablation of the organ. But such an operation is tedious.

The order of examination of the abdomen, as recommended by Virchow,¹ is as follows:—

- (1) The omentum.
- (2) The spleen.
- (3) The left kidney, supra-renal capsule, and ureter.
- (4) The right kidney, supra-renal capsule, and ureter.
- (5) The bladder, prostate gland, vesiculæ seminales, and urethra.
- (6) (a) The testicles, spermatic cord, and penis.
(b) Vagina, uterus, Fallopian tubes, and ovaries, etc.
- (7) The rectum.
- (8) The duodenum and intestinal portion of the ductus communis choledochus.
- (9) The stomach.
- (10) The hepato duodenal ligament, gall-ducts, vena portæ, gall-bladder, and liver.
- (11) The pancreas and semilunar ganglia.
- (12) The mesentery, with its glands, vessels, etc.
- (13) The small and large intestines.
- (14) The retro-peritoneal lymphatic glands, receptaculum chyli, aorta, and vena cava inferior.

In the event of an abdominal incision being impracticable, it is well to know that not only the pelvic organs, but all the abdominal organs, can be removed *per vaginam*. The liver alone would have to be divided with scissors before removal.

Thorax. Virchow¹ has given the general direction that, after the abdomen is opened and the general relations of the organs made out, the thoracic organs should be next studied *in situ*. In a word, all the *relations* of the organs in both great visceral chambers should be ascertained before proceeding to the dissection of either. If ordinary care be taken concerning the wounding of the Diaphragm, or the escaping of blood from the larger veins, the thoracic relations need not be of necessity disturbed. The preservation of the arch of the Diaphragm—its height—its relations to the liver and the chest-wall, however, *must* be made out before the thorax is opened. No case of hepatic abscess, peri-hepatitis, diaphragmitis, pleurisy, pericarditis, ascites, peritonitis, not to mention wounds and fractures of the ribs, can be satisfactorily studied un-

¹ R. Virchow, Method of Performing Post-mortem Examinations. Trans. by T. P. Smith.

¹ L. c., p. 22.

less the post-mortem examination of the Diaphragm be made accurately before its points of insertion, or the pressure to which it had been subject during life, had been disturbed.

To open the chest an incision should be made, extending from the centre of the inter-clavicular space downward to be continuous with the abdominal incision. The skin is quickly turned to either side by long sweeping cuts of the knife, the edge of which should keep close to the chest-wall, and expose the ribs at every stroke; the cleaner the exposure, the easier becomes the work of preparation for opening the chest-wall. Upon approaching the false ribs, the upper flaps, already made from the abdomen, should be held up, and the knife made to divide the slips of origin of the oblique muscles, so as to leave the lower ribs as clean as the upper. If the subject be young, the costal cartilages may be divided by a stout knife or costatome, immediately to the inner side of the sternal ends of the ribs, and a transverse section joining the longitudinal ones, about the line of the middle of the second costal cartilage. The last-named line will sever the manubrio-gladiolar junction. If, however, the parts mentioned are ossified, the saw must follow the lines of the incisions as given. Ordinarily, the saw is used for dividing the cartilages, and the knife for dividing the sterno-clavicular articulation.

The procedure of severing the attachment between the clavicle and the sternum is best effected as follows: Divide the first costal cartilage by an oblique incision from below upward and inward toward the under surface of the joint. This allows the knife to enter the joint at the lower edge of the sternal facet. Care should be taken to avoid opening the innominate vein. In opening the joint from above, more especially if the first costal cartilage be not first divided, the vein is often entered by the incautious use of the knife. The escape of blood into the pleural cavities is always unfortunate. The pleuræ become smeared with blood, disguising their true appearance, and the serous fluid is lost.—Sawing through bone (either of rib or sternum) should be avoided when possible. If the section with the saw is compulsory, the edges should be covered with towelling to protect the hands of the operator.

Littlejohn¹ has advised that, before the Diaphragm is raised, after the costal cartilage and diaphragmatic attachments have been divided, "the hand should be passed up into the anterior mediastinum, breaking

up the connective tissue, and exposing to the touch the organs as high as the root of the neck." This procedure frequently enables the operator at once to discover the probable cause of death. Any tumor, whether aneurismal or otherwise, is readily detected, and some general idea obtained as to the size of the heart and of the condition of the lungs. Nothing can be more embarrassing than to mutilate an aneurismal sac in removing the sternum; whereas, the existence of a swelling in the neighborhood of the aorta having been ascertained, greater care is exercised in separating the sternum, and the diseased structures are exposed in an uninjured condition.

The organs should now be described *in situ*.

The Lungs. It is not necessary to remove the lungs in order to examine them. If the object of the examination be to ascertain the general appearance of the parenchyma and pleura, the root of the lung need not be disturbed, but using it as a fixed point, the lung can be raised from its position and (by inserting a towel or large sponge in the pleural cavity) the organ can be thrown up above the plane of the body, placed thus in a good light, while such section or measurement is made as may be thought necessary.

The Heart. The heart, from the delicacy of its mechanism, the complexity of its several parts, and the great importance frequently attached to its examination after death, is to be studied with great care, and the necessary section to explore its interior is to be made with precision.

After the pericardium is opened, the serum therein contained should be removed by a syringe and measured. The same instrument should be used in withdrawing any fluid from the body, rather than a sponge, which is of necessity a much less accurate aid. Each chamber of the heart should be opened separately, but in such manner as to cause the least amount of injury to the valves, septa, and the orifices of the veins and arteries.

The incisions proposed by Virchow (l. c., p. 36) are as follows:—

For Right Auricle, beginning half way between the planes of entrance of the venæ cavæ, and ending just in front of the base.

For Right Ventricle, beginning close to the base and carried nearly, but not quite, to apex; if carried too far toward the apex, the septæ will be injured.

For Left Auricle beginning at the left superior pulmonary vein, and ending in like manner just in front of the base, which is usually indicated by the very prominent coronary vein. The coronary veins should be carefully avoided.

¹ Edinburgh Med. Journ., 1876, 1113.

For the Left Ventricle, beginning behind the base, and ending short of the apex.

In making the incisions on the right side, the heart is held in the left hand, and rotated toward the left, so as to bring the right lateral border uppermost. In making those of the left side, the heart is seized toward the apex, drawn inward and to the left, while the thick close-set lateral wall is caused to bulge out by gentle pressure.

After the blood has been removed from the cavities and examined, the heart is severed at its base by dividing the great vessels, a fair distance from the heart, and the pulmonary arteries and veins at the roots of the lungs.

After removal, the capacity of the ventricles and the accuracy of closure are approximately determined by pouring water downward into the auricles and great vessels.

This is a reasonably accurate test for the semilunar valves, since they are normally closed by the recoils of the blood sent into the pulmonary artery or aorta, back against the cups of the valves. For the auriculo-ventricular valves, however, it is necessarily imperfect, since the force of the water does not imitate the normal act of closure, which is intricate, and cannot be performed apart from the living organism.

The sections for the study of the valves are selected by following the lines of the natural passage of the blood. Incisions should be made with care through the anterior wall of the right ventricle to avoid injuring the anterior papillary muscle, the moderator band, and the small septal leaflet of the tricuspid valve.

In opening the left auriculo-ventricular valve, it should be remembered how distinct its axis is as compared to that of the right side, and that one of the leaflets of the valve lies close to the septum, and may be injured by incautious adherence to a line too near that structure. By inserting the finger from the right ventricle upward along the pulmonary artery or from the left ventricle along the aorta until the anterior of the three corpora aurantii is felt, a pair of blunt-pointed scissors may be passed along the finger and the valve be divided without liability of injuring the leaflets.

In the event of disease involving the entire respiratory tract, or when the lesion is one requiring careful dissection of the parts at the base of the heart or the root of the lung, the best plan of procedure, after the organs have been carefully studied in position, and surrounding circumstances favoring, is to remove the thoracic viscera *en masse* inclusive of the trachea,

larynx, and hyoid bone. This can be easily effected by making a vertical incision through the skin along the median line of the neck (the sternum having been previously removed), and the soft parts roughly dissected to the sides. A transverse incision is now made above the hyoid bone downward to the vertebral column. The trachea is next seized with the left hand and pulled downward toward the thorax, the knife being held in the right hand in order to divide the vessels at the root of the neck as they become tense under the downward strain. Below the position of these vessels no obstruction exists to the easy separation of the aorta and other parts from the front of the vertebral column, and the evulsion of the entire contents of the thorax over the abdomen is soon accomplished. The removal of the various points of attachment is soon accomplished, and the organs can be placed aside in a preservative fluid for detailed study.

In rupture of the aorta into the pericardium, when the orifice is so small as to escape notice, it is recommended by Littlejohn¹ to incise the left ventricle and pass the forefinger of the right hand into the aorta. "As the ruptured orifice is generally situated anteriorly, by simply pressing the finger against the wall of the vessel the slightest depression is detected, and then, on closer examination, the minute rupture is detected. Should any doubt remain, the aorta may be compressed at the arch, and some water injected upwards from the ventricle, when a tiny jet will quickly determine the site of the aperture."

The Brain. This is examined after the abdomen and thorax. If it be examined first, the escape of venous blood from the sinuses will drain venous blood (particularly if the head is allowed to remain pendent from the edge of the dissecting table, as is often the case) from the venæ cavæ and heart. It is evident, however, that the reverse of this proposition is true, and if in the judgment of the operator the condition of the parts in the skull be of greater importance than those of the trunkal cavities, there can be nothing to oppose, but, on the contrary, everything to favor the examination of the head before opening either the abdomen or the thorax.

To examine and remove the brain the sections must be as follows: With a sharp knife the operator should penetrate the scalp over the ear, and, keeping the point upward, cut the scalp from within outward, while the section is made toward the vertex, and from that region downward to the ear of the opposite side.

¹ Edinburgh Med. Journ., 1876, 1116.

In this manner the scalp is divided from ear to ear (the hair being but little injured), and forms two flaps which can be easily retracted to expose the skull. The skull should now be sawed in such manner as to make a circular section round the head, a little above the ear. To avoid the inconvenience of using the saw at the occiput, upon which point the weight of the skull rests, some physicians confine the circular incision to the frontal and temporal regions, and join its ends by an oblique rim extending upward and backward between the occipital protuberance and the lambdoidal suture. There can be no objection to the latter section where removal of the brain is alone intended. It has, indeed, the advantage of holding the skullcap in better position than when the circular incision is employed. The incision first named is to be preferred when the brain is to be studied *in situ*, and the skull preserved. Neither should there be any difficulty in readjusting the round-based skullcap. Hard wooden pegs, or, what is perhaps better, iron brads, can be driven in the diploë of the occipital and lateral parts of the frontal bone, and the free projecting ends sharpened to a point. The skullcap can be fitted thereto by placing the ends of the pegs or brads in the diploë, and firmly forcing the skullcap downward. Dr. Chas. K. Mills¹ recommends, in making the section which will expose the brain-case, that the Temporal muscle-fibres be left on the skull-cap, as a few stitches through the divided ends of the muscle assist materially in holding the skull-cap in position. The saw need not pass entirely through the skull. A few strokes of the hammer on the chisel of the post-mortem set will suffice to sever the inner brittle plate. It is, perhaps, unnecessary to point out the fact that the skull is thinner at the temporal region than elsewhere, and is least thin at the occiput. The incautious operator may injure the brain at the former point long before he has reached the inner plate at the latter. The dura mater may be cut through along the line of the section made by the saw, and thus, should it be adherent to the skullcap, may be removed therewith, the scissors being used to divide the points of union with the great longitudinal falx. It has been advised, especially in the autopsies of children, to saw through both bone and brain together, in cases where the study of the form of the brain is a matter of little importance. After the skullcap and dura mater have been removed, and the pia mater exposed, the condition of the bloodvessels

should be studied with care, and both sides of the pia mater examined. The base should not be disturbed until the condition of the superficies, corpus callosum, and the quantity of fluid in the ventricles have been ascertained. Removal of the brain under the most favorable circumstances lacerates the already softened structures. Even in the normal brain, the falling outward of the cerebral hemispheres (now no longer supported by the sides of the skull and falx) will sever the middle commissure of the third ventricle. The brain, while yet in position, will permit the lateral ventricles being opened by a vertical section made a half inch to the outer side of the great longitudinal fissure downward to the lateral ventricle, which being thus opened, a syringe furnished with a long nozzle may be used to withdraw the fluid.

In suspected fracture of the cranium, special care must be taken to avoid the blows of the mallet in any way complicating the lesion. The same writer advises that the saw should never pass further than fairly into the diploë, and whenever practicable the so-called inner plate be left intact. Instead of the mallet and chisel, he recommends that the chisel alone be used. "A stout piece of steel is loosely fitted by an aperture to the chisel edge, and, gravitating by its weight, is arrested at the shoulder of the instrument, thus forming a cross where the two portions are adjusted. By sawing deeply over the frontal sinus, the sharp edge of the chisel is easily inserted; and by simply turning the chisel round, the internal plate at once gives way with a slight crack, and the skullcap is felt to be detached."

The interior of the calvarium should be carefully examined for evidence of fracture.

In removing the brain the anterior portion of the cerebrum should be gently raised and all the cranial nerves be severed at their points of exit through the floor of the brain-case. The tentorium is next slit from side to side, and the medulla oblongata severed from the spinal cord by making an oblique cut with a long knife as far down in the vertebral canal as is possible. The pituitary body, by a *tour de force*, can be removed with the brain, the pedicle remaining intact. Ordinarily, however, this body is left in the pituitary fossa. The brain when removed should be placed base upward in a shallow vessel with curved sides, such as a tin wash-basin, to avoid the falling outward of the hemispheres. Perhaps the best plan is to invert the brain in the skullcap, and place the latter top downward in a towel folded loosely in the basin. Prof. Burt G. Wilder recommends dividing the brain longitudinally in the median line, and placing the

¹ Phila. Med. Times, 1880, vol. x. 365.

median surfaces downward upon the bottom of a flat dish. The subsequent examination of the brain must be conducted according to the immediate object in view. Indiscriminate slicing of the organ is to be avoided. If the intention is to determine the general condition of the parts without reference to any minute study of the texture of the organ, the examination may begin by exposing the lateral ventricles. The incisions made as above recommended to expose these cavities with a view of collecting the fluid, manifestly cannot be made to any advantage after the brain has been removed from the head. Conceding, therefore, that such incisions have already been made, a narrow knife is next passed through the foramen of Monro, and the corpus callosum and the fornix divided transversely. These parts are turned back in order to display the cavity of the third ventricle. The horns of the lateral ventricle can be slit up by an incision extending along their entire lengths. The velum body and the pincal interpositum are next examined, the greatest care being required—owing to the intimate association existing between it and the fibres of the velum—to preserve the pineal body uninjured. A director is next passed along the communicating passage between the third and fourth ventricles, and the superimposed tissue divided. The cerebrum is next usually sliced from within outwards in crude imitation of the compartments of an orange, viz., each section being narrow toward the lateral ventricle, but wide toward the outer surface. The object of such treatment is to examine carefully for alterations of a morbid character, and to permit the different compartments or divisions to be examined at will and returned to their natural relations. This method further aids the preservation of the tissues by permitting the selected fluid to permeate through the entire thickness of the cerebrum. To display the relations of the nuclei of the striated body one to another and to the cortex horizontal sections may be made in the manner used to demonstrate the arbitrary planes of the cerebrum, viz., the lesser and greater oral sections. In the language of Dr. Mills (l. c.) the cerebrum may be divided, according to the method of M. Pitres (see p. 508), as follows:—

“The first incision is made through the præ-frontal region, the second, through the bases of the three frontal convolutions, the third, through the ascending frontal convolution, the fourth, through the ascending parietal convolution, the fifth, through the superior and inferior parietal lobules, and the sixth, through the occipital lobe. The incisions should be made in

each hemisphere from within outwards nearly to the convolutions.

“Instead of the vertico-transverse, the vertico-longitudinal section may be used. In this method beginning at the cerebral peduncles, smooth incisions long and deep enough to expose all the parts to within a few lines of the convolutions of the base should be carried through both optic thalami and corpora striata and out into the hemispheres, a few extra sections being made in the white matter above the level of the ventricles.

“It may sometimes be desirable to examine the interior of the cerebrum from the base, which can be readily done, particularly if a fair knowledge on the part of the operator is possessed of the relations of the fissures and convolutions of the surface to internal eminences and cavities.”

The Spinal Cord. The spinal cord can be removed with advantage as follows: After severing the laminae of the vertebrae by the saw or with pliers, sever the dura mater and the cord at the level of the foramen magnum. The membranes and the cord at the plane of this section are then lifted together from the vertebral canal, the nerves, and the filum terminale being successively divided, the entire cord with the membranes are removed. The dura mater and the pia mater may then be slit and the surface of the cord inspected; subsequently the specimen may be divided in sections of convenient length and immersed in an appropriate preservative fluid.

The Ear and Nasal Chambers. To the student of nasal and aural diseases it often becomes desirable to remove the nasal chambers and the ears for special study. Schalle¹ has written an elaborate paper descriptive of a process original with himself which is undoubtedly the best that has yet been offered to effect this object. The essential feature of his method is the removal of all the parts of interest, which cannot be inspected upon the undissected body, and the securing of such without mutilation of the features, or the making of unsightly seams.

After removal of the skullcap and the brain, as already described, a trifoil-like figure is traced upon the floor of the brain-case so as to include in the anterior leaflet the anterior part of the basilar process of the occipital bone, the body and basal portions of the greater and lesser wings of the sphenoid bone, and the inner halves of the orbital plates of the frontal

¹ Virchow's Archiv, vol. 71, 1877, 206, Pl. ix. The plate displays the line to be followed by the saw, a figure of the parts removed, and of the instruments employed.

bone (inclusive of the cribriform plate of the ethmoid), while the petrous portions of the temporal bone lie in the lateral leaflets. The junction of the anterior leaflet and the lateral leaflets is secured at a point answering to the bottom of the glenoid fossa, which in the brain-case answers to a point at the base of the petrosal eminence at the lateral half of the middle cerebral fossa. It is to be understood from the onset that a section of the skull the shape and size of the trifoil figure is to be removed by vertical section. The essential feature of the procedure is to insert a narrow saw-blade of a bow-saw through an opening made through the middle cerebral fossa at the point indicated, and the section made by sawing out vertically the pattern of the trifoil.

The plan being thus understood, Schalle begins the dissection of the parts outside the brain-case as follows:—

An incision is made with a stout scalpel over both clavicles, from one acromial process to the other. The head and neck are next made to fall by a shoulder-block being thrust beneath the scapula, and the incision continued upward, along one side of the neck to an inch and a half above and behind the external auditory meatus, and is here made continuous with the transverse incision across the vertex already made for removal of the skullcap. It now descends on the opposite side of the neck, and meets the acromial end of the first trans-clavicular incision. This long and bold cut can be well covered subsequently by the clothing, and permits of free manipulation of parts lying between the limits of the incision, both in front and behind.

The anterior flap is turned down over the face to the brows, and laterally, by free incision through the cartilaginous external auditory meatus, to over the cheeks. Next the anterior flap is raised from the clavicles to the lower jaw. The structures of the supra-hyoid region, *viz.*, the Genio hyoid, Mylo-hyoid, Ilyo-glossus, Genio-glossus, and D'gastric muscles, the facial arteries, etc., are divided, and the tongue drawn down and out of the mouth upon the neck. The palato-glossal and pharyngo-glossal connections are next divided, the pharynx severed about on the level of the aperture of the larynx, and the entire hyoid apparatus with the tongue pulled toward the sternum, thus leaving a free space for manipulation upon the under part of the skull. The Pterygoid muscles are now separated from the lower jaw, the temporomaxillary articulation opened from within, and the lower jaw drawn forward, so as to rest upon the articular eminence in advance of the glenoid fossa.

The molar teeth in the upper jaw are now extracted to avoid the resistance they would offer to the action of the saw.

The posterior wall of the pharynx is next removed from in front of the vertebral column, and as far as possible from the roof of the pharynx. All the space needed is secured. It is now necessary to fix the lower jaw in its forward position at the chin, and to steady the skull while the bottom of the glenoid fossa is perforated to permit the use of the saw, which is made to perform a circuit, cutting out in the shape of a trifoil-cylinder the cavity of the nose and both petrous portions of the temporal bone. The saw should pass between the crista galli and the foramen cæcum in front, close to the squamous portion of the temporal bone at the sides and about midway between the foramen magnum and the occipito-sphenoidal junction, behind.

When the section is complete it can be removed from above by gentle pressure on the hard palate. The specimen will not include the anterior half of the superior maxilla, the anterior ethmoidal cells, the anterior part of the inferior turbinate bone, the interior of the external nose, nor the outer posterior part of the mastoid process. These should, therefore, be carefully inspected in the cadaver before closing the parts.

To effect the latter the lower jaw must be readjusted to the portion of the glenoid fossa yet remaining in position, the tongue and hyoid apparatus replaced. The brain-case is filled with some light absorbent material, such as sawdust or oakum, and the remains of the eyeballs pushed outwards—since the section has, of necessity, included part of the orbital contents. The skullcap is restored in the ordinary way, and the skin-flaps readjusted. This manipulation appears at first sight laborious, and would doubtless prove so to a tyro. To one accustomed to the use of instruments no great degree of difficulty need be anticipated.

It is likely that the use of the dental engine, in lieu of the bow-saw, would greatly facilitate making the section.

Foulis¹ advocates an examination of the middle ear by splitting the petrous portion of the temporal bone with a chisel along a line parallel to the squamous plate, directly to the outer slope of the eminence caused by the superior semicircular canal. The tympanum is opened by this procedure, as well as the mastoid cells, while the stapes is usually separated from the incus. Should a particular examination of

¹ British Med. Journ., April 24, 1880.

the inner ear be desired, the loose bits of the "petrous bone" might be again divided in various directions according to the demands of the case. This method, while confessedly crude, may be of some value where circumstances do not permit of more systematic exploration.

The Eye. The removal of the eye, when it is not deemed important to extirpate the entire globe, can be easily accomplished by breaking through the brittle orbital plate, and dividing the eyeball transversely immediately behind the corneo-scleral junction. The eyeball, thus mutilated, is then lifted from its bed,

the insertion of the peri-ocular muscles divided, and the nerve severed.

The Bones. It often becomes necessary to saw the long bones longitudinally. The selected bone should be fixed in a vise, and the section made by the ordinary saw of the post-mortem case. If a gig-saw be available, especially one run by steam-power, the operator will save much time and trouble by securing the assistance of a workman skilled in the use of such a machine. The section by this means is made with great celerity and precision in any desired direction.

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A SYSTEM
OF
HUMAN ANATOMY,

INCLUDING ITS
MEDICAL AND SURGICAL RELATIONS.

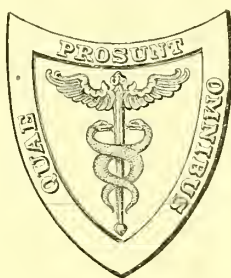
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WITH A
SECTION ON HISTOLOGY.

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ILLUSTRATED WITH THREE HUNDRED AND EIGHTY FIGURES
ON
ONE HUNDRED AND NINE FULL-PAGE LITHOGRAPHIC PLATES, MANY OF WHICH ARE BEAUTIFULLY COLORED.
THE DRAWINGS BY HERMANN FABER, MOSTLY FROM DISSECTIONS BY THE AUTHOR.

ALSO TWO HUNDRED AND FORTY-ONE WOODCUTS IN THE TEXT.



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P R E F A C E .

THE essentially modern science of Clinical Anatomy may be said to owe its origin to the notable activity which characterized the study of the human body during the last quarter of the eighteenth century. In France, the writings of Portal and Cruveilhier, in Great Britain, those of the first Monro, of William and John Hunter, and of Charles Bell, and in Germany, those of Luschka and Hyrtl attest the fact that the plan of uniting Clinical and Descriptive Anatomy in one volume has the sanction of, if it did not receive its first impress from, the men who have largely contributed to make the science of human anatomy what it now is.

But a more intimate union between anatomical and clinical studies has been advocated of late years by the clinicians themselves. The most exhaustive analyses of subjects which are treated after the method of the general anatomist oftentimes will leave points of structure—when the test of clinical study is applied to them—imperfectly exhibited, since the special lines of practical work will suggest comparisons in health and disease which will be naturally left to the clinician to elaborate.

It is necessary, as Charcot declares, to exclude as valueless all observations on the diseases and lesions of the brain in which the topography of the lesion is not indicated with rigorous exactitude. The student of anatomy who is at the same time a student of neurology is thus induced to examine with renewed care and increased zeal the ground of the anatomy of the central nervous system. As an outcome of this, the researches of representative workers such as Meynert, Wernicke, Türk, and Flechsig have thrown, for the first time, light and meaning upon the minute structure of the brain and of the spinal cord. In like manner, Adams and Hancock became authorities on the anatomy of the foot; Curling, on the anatomy of the testicle; Sibson, on the regional anatomy of the viscera; and Politzer and Urbantschitsch, on the anatomy of the ear, etc. Is it not going to the very heart of a correct anatomical method to follow students such as these, and to learn of them the way in which the facts of descriptive anatomy should be presented? Do not such workers in effect tell us that the interest taken in the study of the structure of the human body is prospective only, the exact value not being determined until the clinical application of knowledge concerning these structures has been stated? If this position be correctly taken, is not the proper basis of anatomical teaching the union of the descriptive and the clinical data at the time when the reader is receiving first impressions of this great subject?

There are, doubtless, many anatomical facts which have no practical application. The number of these, however, is rapidly diminishing; and even in the imperfect record of this book it will be observed that there are few subjects concerning which a clinical comment cannot be made. In the selection of representative cases which illustrate anatomical themes, care has been taken to accept

none in which the facts set forth were not clearly demonstrated; and with this limitation in mind, attempts have been made to present an outline of the clinical biography, so to speak, of each and every part of the economy, and to note, however briefly, the varied and momentous deviations from the normal structure which it has revealed.

The attempt to introduce a modified *nomenclature* such as that proposed by Prof. Burt G. Wilder has not been carried to the extent the author would have desired. The profession is conservative, and no reasonable expectation can be entertained that the nomenclature now in use—with all its absurdities and imperfections—will be materially modified until a congress of teachers, convened for the purpose, agree upon a list of terms which will be introduced into the text-books and which will be employed in teaching.

The main object the author has had in view in using terms which are not in general use was to facilitate the task of describing the structures of the body. There is some prospect that the terms “median” and “lateral” will come into use; and it is reasonably certain that when an observer accustoms himself to such terms he will unwillingly relinquish them. “Internal” and “external” are often used synonymously with “median” and “lateral.” But in some relations “internal” might be confounded with the “interior” of the body or of an organ, and “external” with the superficies. Yet “median” and “lateral” are awkward terms when applied to the teeth, and cannot in this instance be employed with advantage. In descriptions of spheroidal figures, as the eyeball, or forms which are derivative of the same, as the auditory labyrinth, the terms “meridional plane” and “equatorial plane” are more appropriate. In like manner the terms “frontal” or its equivalents “coronal” and “sagittal” are becoming more and more frequent in English writings.

In the preparation of the work the author has received assistance from many of his friends, among whom he desires particularly to express acknowledgments to Drs. N. Archer Randolph, J. William White, Chas. H. Burnett, B. Alexander Randall, and George A. Piersol. Dr. John B. Deaver rendered valuable aid in revising the proofs of the last section. Dr. E. C. Spitzka kindly assisted in reading the proofs of the minute anatomy of the nervous system.

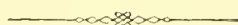
To Drs. Albert H. Smith, Wm. F. Norris, Alfred Stillé, S. Weir Mitchell, A. Van Harlingen, A. G. Heyl, H. F. Formad, J. Solis Cohen, and G. Davis, the author desires to return his thanks for the loan of books and for other courtesies.

For the opportunity of using the section of the brain shown in figure 94, and those shown in figures 97 to 102—all of which are from preparations of Dr. Schmidt’s—the author is indebted to the Committee on the Mütter Museum of the College of Physicians of Philadelphia.

In conclusion, the author wishes to express his lasting sense of obligation to those noble men who sustain the library of the College of Physicians of Philadelphia, and who, by a liberal and intelligent policy, enable its books to be loaned to the Fellows. By the aid afforded through such ruling the author’s labors have been greatly facilitated.

PHILADELPHIA, September, 1884.

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